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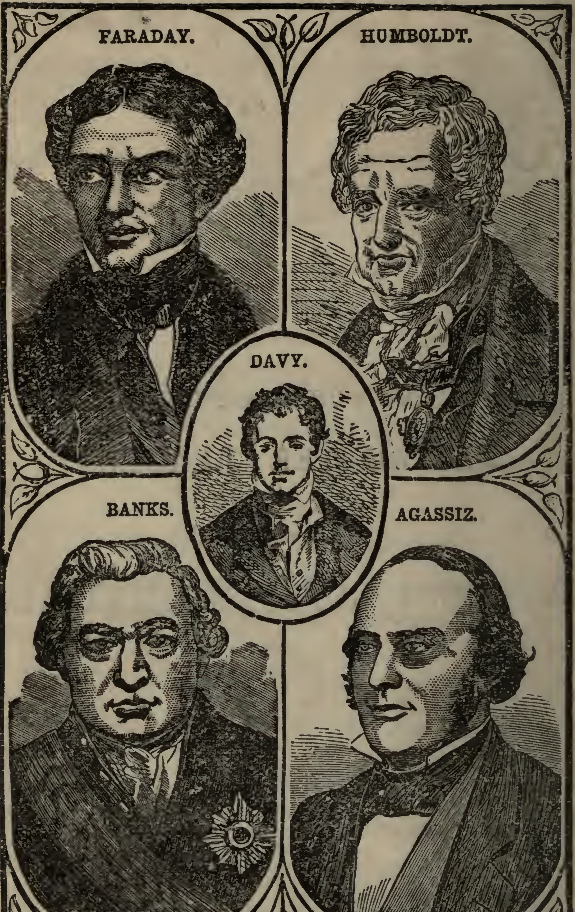


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*** In all schools, the children in Standards V. and VI. should know the principles of the Metric System, and be able to explain the advantages to be gained from uniformity in the method of forming multiples and sub-multiples of the unit.

# PREFACE.

As many teachers have expressed a wish to have more than one reading book in the MANCHESTER READERS suitable to the requirements of Standards V. and VI., the Publisher, in deference to their desire, has caused some Readers on special subjects to be prepared, which may be considered as Supplementary to the "FIFTH MANCHESTER READER," and which meet in every respect the requirements of the Standards to which reference has just been made. Thus there will for the future be no necessity for obliging learners to go over the same ground again and again until teacher and pupil are wearied of the reiteration, but as soon as the Fifth Book has been thoroughly mastered the learners may pass onward to the SUPPLEMENTARY MANCHESTER READERS, which will open up to them new fields of information of interesting and varied character.

Of these Supplementary reading-books the SCIENTIFIC READER is the first. In this will be found reading lessons in most branches of science to which it is desirable to call the attention of the youthful learner. It will be at once understood that the leading principles only of the various sciences that are brought under consideration are touched on, as it is manifestly impossible to do more in a lesson which is intended rather for class reading than for private study, with a view to examination in science subjects. The SCIENTIFIC READER is intended, in fact, to serve the purpose of a finger-post to the sciences, and not that of a treatise or series of treatises on the sciences themselves; but for those who require further information in detail care has been taken to point out where such information may be found by direct references to the "CLASS BOOK OF MODERN SCIENCE," in which it may be found. To show the range of subjects embraced in the SCIENTIFIC READER it will be sufficient to say that lessons bearing on Zoology, Botany, Mineralogy, Geology, Astronomy, Architecture, and Physical Geography are given, in combination with others on the Properties of Matter, the Laws of Motion, Mechanics, the Pressure and Motion of Liquids, the Atmosphere, Sound, the Eye, Heat, Meteorology, Electricity, and Chemistry.

In the **Notes** that follow many of the lessons, brief biographical sketches have been given of the principal men of eminence mentioned in the text, with other information specially referring to points touched on therein. To some of the lessons a **Glossary of Difficult Words and Scientific Terms** has been prefixed, giving the appropriate meaning and derivation of each word; to others lists of words of a similar kind have been appended as **Exercises in Meanings and Derivation** for the pupil to prepare after the manner of the Glossaries. It may be suggested to teachers that these exercises may be used as **Class-lessons in Dictation**; the teacher giving out each word in such a manner as to mark clearly its division and accentuation, following this with its meaning and derivation. The derivation of almost any word that does not readily suggest itself may be obtained from "Chambers's Etymological Dictionary of the English Language," a work that should be in the hands of every teacher and pupil-teacher. When necessary, the text has been illustrated by diagrams, and occasional **Exercises in Dictation** have been introduced embodying interesting facts connected with science.

# CONTENTS.

# THE MANCHESTER
# SCIENTIFIC READER.

## THE PLEASURES AND ADVANTAGES OF SCIENCE.

[*Abridged from Lord Brougham's treatise—" On the Objects, Pleasures, and Advantages of Science."*]

Man is composed of two parts, body and mind, connected indeed together, but wholly different from one another. Each has its uses, and each has its peculiar gratifications. The bounty of Providence has given us outward senses to be employed, and has furnished the means of gratifying them in various kind and in ample measure. As long as we only taste those pleasures according to the rules of prudence and our duty, that is, in moderation for our own sakes, and in harmlessness towards our neighbours, we fulfil rather than thwart the purpose of our being. But the same bountiful Providence has endowed us with the higher nature also—with understanding as well as senses—with faculties that are of a more exalted order, and admit of more refined enjoyments than any to which the bodily frame can minister; and by pursuing such gratifications, rather than those of mere sense, we fulfil the most exalted ends of our creation, and obtain both a present and a future reward. These things are often said, but they are not therefore the less true, or the less worthy of deep attention. Let us mark their practical application to the occupations and enjoyments of all branches of society, beginning with those who form the great bulk of every community, the working classes, by what names soever their vocations may be called—professions, arts, trades, handicrafts, or common labour.

The first object of every man who has to depend upon his own exertions must needs be to provide for his daily wants. All other pursuits must give way to this; the hours which he devotes to learning must be after he has done his work; his independence, without which he is not fit to be called a man, requires first of all that he should have insured for himself, and those dependent on him, a comfortable subsistence, before he can have a right to taste any indulgence either of his senses or of his mind; and the more he learns—the greater progress he makes in the sciences—the more will he value that independence, and the more will he prize the industry, the habits of regular labour, whereby he is enabled to secure so prime a blessing.

In one view, it is true, the progress which he makes in science may help his ordinary exertions, the main business of every man's life. There is hardly any trade or occupation in which useful lessons may not be learnt by studying one science or another. To how many kinds of workmen must a knowledge of Mechanical Philosophy be useful. To how many others does Chemistry prove almost necessary. Every one must with a glance perceive that to engineers, watch-makers, instrument-makers, bleachers, and dyers, those sciences are most useful, if not necessary. But carpenters and masons are surely likely to do their work better for knowing how to measure, which Practical Mathematics teaches them, and how to estimate the strength of timber, of walls, and of arches, which they learn from Practical Mechanics; and they who work in various metals are certain to be the more skilful in their trades for knowing the nature of those substances, and their relations to both heat and other metals, and to the gases and liquids they come in contact with. Nay, the farm servant or day labourer, whether in his master's employ or tending the concerns of his own cottage, must derive great practical benefit—must be both a better servant and a more thrifty and therefore comfortable cottager, for knowing something of the nature of soils and manures which Chemistry teaches, and something of the habits of animals, and the qualities and growth of plants, which he learns from Natural History and Chemistry together. This, then, is

the *first* use of learning the principles of science: it makes men more skilful, expert, and useful in the particular kinds of work by which they are to earn their bread, and by which they are to make it go far and taste well when earned.

But another use of such knowledge to handicraftsmen is equally obvious: it gives every man a chance, according to his natural talents, of becoming an improver of the art he works at, and even a discoverer in the sciences connected with it. Very few great discoveries have been made by chance and by ignorant persons; much fewer than is generally supposed. It is commonly told of the steam-engine, that an idle boy being employed to stop and open a valve, saw that he could save himself the trouble of attending and watching it by fixing a plug upon a part of the machine which came to the place at the proper time in consequence of the general movement. This is possible, no doubt, though nothing very certain is known respecting the origin of the story; but improvements of any value are seldom indeed so easily found out, and hardly another instance can be named of important discoveries so purely accidental. They are generally made by persons of competent knowledge, and who are in search of them. The improvements of the steam engine by Watts resulted from the most learned investigation of mathematical, mechanical, and chemical truths. Arkwright devoted many years, five at least, to his invention of spinning jennies, and he was a man perfectly conversant in everything that relates to the construction of machinery: he had minutely examined it and knew the effects of each part, though he had not received anything like a scientific education. If he had, we should in all probability have been indebted to him for scientific discoveries as well as practical improvements. The most beautiful and useful inventions of late times, the safety-lamp, was the reward of a series of philosophical experiments made by Sir Humphrey Davy, one who was thoroughly skilled in every branch of chemical science. But in so far as chance has anything to do with discovery, surely it is worth the while of those who are constantly working in particular employments to obtain the knowledge

required, because their chances are greater than other people's of so applying that knowledge as to hit upon new and useful ideas: they are always in the way of perceiving what is wanting, or what is amiss in the old methods; and they have a better chance of making the improvements. This, then, is the *second* great use of learning the sciences: it enables men to make improvements in the arts, and discoveries in philosophy, which may directly benefit themselves and mankind.

Now, these are the *practical* advantages of learning; but the *third* benefit is, when rightly considered, just as practical as the other two—the pleasure derived from mere knowledge, without any view to our own bodily enjoyments; and this applies to all classes, the idle as well as the industrious, if, indeed, it be not peculiarly applicable to those who enjoy the inestimable blessing of having time at their command. That every man is capable of being delighted with extending his information upon matters of science will be evident from a few plain considerations.

Reflect how many parts of the reading, even of persons ignorant of all sciences, refer to matters wholly unconnected with any interest or advantage to be derived from the knowledge acquired. Everyone is amused with reading a story; a romance may divert some, and a fairy tale may entertain others; but no benefit beyond the amusement is derived from this source. The imagination is gratified; and we willingly spend a good deal of time and a little money in this gratification, rather than in resting after fatigue, or in any other bodily indulgence. So we read a newspaper without any view to the advantage we are to gain from learning the news, but because it interests and amuses us to know what is passing. This pleasure is greatly increased when the information is such as excite our surprise, wonder, or admiration. Most persons who take delight in reading tales of ghosts, which they know to be false, are merely gratified, or rather occupied, with the strong emotions of horror excited by the momentary belief, for it can only last an instant. Such reading is a degrading waste of precious time, and has even a bad effect upon the feelings and judgment. But true stories of horrid crimes,

as murders and pitiable misfortunes, as shipwrecks, are not much more instructive. It may be better to read these than to sit yawning and idle—much better than to sit drinking or gaming, which, when carried to the least excess, are crimes in themselves and the fruitful parents of many more. But this is nearly as much as can be said for such vain and unprofitable reading. If it be a pleasure to gratify curiosity, to know what we were ignorant of, to have our feelings of wonder called forth, how pure a delight of this very kind does Natural Science hold out to its students. Recollect some of the extraordinary discoveries of Mechanical Philosophy. How wonderful are the laws that regulate the motion of fluids! Is there anything in all the idle books of tales and horrors more truly astonishing than the fact that a few pounds of water may by mere pressure, without any machinery, by being merely placed in a particular way, produce an irresistible force? What can be more strange than that an ounce weight should balance hundreds of pounds by the intervention of a few bars of thin iron? Observe the extraordinary truths that Optical Science discloses. Can anything surprise us more than to find that the colour of white is a mixture of all others—that red, and blue, and green, and all the rest, merely by being blended in certain proportions, from what we had fancied rather to be no colour at all, than all colours together? Chemistry is not behind in its wonders. That the diamond should be made of the same material with coal; that water should be chiefly composed of an inflammable substance; that acids should be, for the most part, formed of different kinds of air, and that one of those acids, whose strength can dissolve almost any of the metals, should consist of the self-same ingredients with the common air we breathe; that salts should be of a metallic nature, and composed in great part of metals such as potassium, &c., yet lighter than water, and which, without any heating, take fire upon being exposed to the air, and by burning form the substance so abounding in saltpetre and in the ashes of burnt wood. These, surely, are things to excite the wonder of any reflecting mind—nay, of any one but little accustomed to reflect; and yet these are trifling when

compared to the prodigies which Astronomy opens to our view: the enormous masses of the heavenly bodies; their immense distances; their countless numbers, and their motions, whose swiftness mocks the uttermost efforts of the imagination.

Akin to the pleasure of contemplating new and extraordinary truths is the gratification of a more learned curiosity, by tracing resemblances and relations between things which, to common apprehension, seem widely different. It is surely a satisfaction, for instance, to know that the same thing, or motion, or whatever it is, which causes the sensation of heat causes also fluidity, and expands bodies in all directions; that electricity, the light which is seen on the back of a cat when slightly rubbed on a frosty evening, is the very same matter with the lightning of the clouds; that plants breathe, like ourselves, but differently by day and by night; that the air which burns in our lamps enables a balloon to mount, and causes the globules of the dust of plants to rise, float through the air, and continue their race—in a word, is the immediate cause of vegetation. Nothing can at first view appear less like, or less likely to be caused by the same thing, than the process of burning and of breathing—the rust of metals and burning—an acid and rust—the influence of a plant on the air it grows in by night, and of an animal on the same air at any time; nay, and of a body burning in that air. And yet all these are the same operation. It is an undeniable fact that the very same thing which makes the fire burn makes metals rust, forms acids, and enables plants and animals to breathe; that these operations, so unlike to common eyes, when examined by the light of science are the same—the rusting of metals—the formation of acids—the burning of inflammable bodies—the breathing of animals—and the growth of plants by night. To know this is a positive gratification. Can anything be more strange to contemplate? Is there, in all the fairy tales that were ever fancied, anything more calculated to arrest the attention and to occupy and to gratify the mind than this most unexpected resemblance between things so unlike to the eyes of ordinary beholders? What more pleasing occupation than to see uncovered and

bared before our eyes the very instrument and the process by which Nature works? Then we raise our views to the structure of the heavens, and are again gratified by tracing accurate but most unexpected resemblances. Is it not in the highest degree interesting to find that the power which keeps this earth in its shape and in its path, wheeling upon its axis and round the sun, extends over all the other worlds that compose the universe, and gives to each its proper place and motion; that this same power keeps the moon in her path round our earth, and our earth in its path round the sun, and each planet in its path; that the same power causes the tides upon our globe, and the peculiar form of the globe itself; and that, after all, it is the same power which makes a stone fall to the ground? To learn these things and to reflect upon them occupies the faculties, fills the mind, and produces certain as well as pure gratification.

The highest of all our gratifications in the contemplation of science remains: we are raised by them to an understanding of the infinite wisdom and goodness which the Creator has displayed in his works. Not a step can we take in any direction without perceiving the most extraordinary traces of design; and the skill everywhere conspicuous is calculated, in so vast a proportion of instances, to promote the happiness of living creatures, and especially of our own kind, that we can feel no hesitation in concluding that, if we knew the whole scheme of Providence, every part would be found in harmony with a plan of absolute benevolence. Independently, however, of this most consoling influence, the delight is inexpressible of being able to follow, as it were, with our eyes the marvellous works of the great Architect of Nature—to trace the unbounded power and exquisite skill which are exhibited in the most minute, as well as the mightiest, parts of His system. The pleasure derived from this study is unceasing, and so varied that it never tires the appetite. But it is unlike the low gratifications of sense in another respect: while those hurt the health, debase the understanding, and corrupt the feelings, this elevates and refines our nature; teaching us to look upon all earthly objects as insignificant and below our

notice, except the pursuit of knowledge and the cultivation of virtue; and giving a dignity and importance to the enjoyment of life, which the frivolous and the grovelling cannot even comprehend.

Let us, then, conclude that the pleasures of science go hand in hand with the solid benefits derived from it; that they tend, unlike other gratifications, not only to make our lives more agreeable but better; and that a rational being is bound, by every motive of interest and of duty, to direct his mind towards pursuits which are found to be the sure path of virtue as well as of happiness.

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*** *The following notes relate to persons and things mentioned in the preceding Reading Lesson. They have been collected at the end of the Lesson instead of being placed as foot-notes in the pages in which the names occur, as foot-notes frequently tend to draw away the attention of the rest of the class from the paragraph to which a note refers, while the paragraph in question is being read aloud by one of their number. The notes are placed in alphabetical order, and no reference is made to them in the text designedly, as it will afford a useful exercise for the pupils to look back through the Lesson after reading it, and pick out the paragraphs to which the notes refer. This course will be adopted in all lessons to which notes may be required.*

## Notes.

1. ARKWRIGHT, Sir Richard, an eminent manufacturer, who advanced himself, by his mechanical inventions for carding and spinning cotton, from the humble station of a country barber to the foremost rank of society. He may be said to have been the founder of the immense trade in manufactured cotton which is carried on by Great Britain at the present day. Born 1732; died 1792.

2. BROUGHAM, Henry, Lord, an eminent lawyer and writer on mathematical and physical science, was born at Edinburgh in 1779. He was called to the Scottish bar in 1800, and to the English bar at Lincoln's Inn in 1808. He entered the House of Commons in 1810, and was raised to the House of Lords as Lord Chancellor in 1830. In 1827 he laid the foundation, in conjunction with Mr. Charles

Knight and others, of the Society for the Diffusion of Useful Knowledge; and was mainly instrumental, with Dr. Birkbeck, in founding Mechanics' Institutes, for the promotion of knowledge among the working classes. He died at Cannes, in the south of France, in 1868.

3. Davy, Sir Humphry, a famous chemist, born in Cornwall in 1778. He was made professor of chemistry in the Royal Institution of London, where he delivered his first lecture in 1802. He discovered several of the principles of voltaic electricity, and by this power reduced certain earths and alkalies to a metallic state. Sir Humphry died of apoplexy at Geneva, in 1829.

4. Potassium, the lightest metal known.—A curious instance of the fallacy of our senses occurred as Sir Humphry Davy was, for the first time, exhibiting to another accomplished chemist the metal potassium, which he had just discovered. His friend admired its perfect metallic character, and, poising it upon his finger, exclaimed, "How heavy!" whereas, potassium is so light that it floats, like cork, on water; but, until then, all the known metals were heavy bodies, and, consequently, the idea of gravity was intimately associated in the mind with metallic lustre. At present, the metals include the heaviest and lightest solids known—platinum and potassium.

5. Safety Lamp. — Sir Humphry Davy, in order to prevent accidents in coal mines, instituted such experiments as led him to discover and apply the principles of the Safety Lamp. Its construction may be thus stated.

The fire-damp is a species of inflammable gas (carburetted hydrogen), which, when mingled with atmospheric air in certain proportions, explodes on contact with flame. To prevent this, Sir Humphry enclosed a lighted lamp within a perfect cage of wire gauze, by which means no flame is enabled to penetrate *from within* to the surrounding medium, in consequence of the cooling power of the metallic tissue, which is referable to its excellent conducting properties for heat, of which it becomes a powerful radiator.

6. Watt, James, a civil engineer, born at Greenock in 1736. He was originally a mathematical instrument maker, but ultimately turned his attention to the improvement of the steam engine, which he was mainly instrumental in bringing to its present pitch of perfection. He was equally famous as a surveyor and engineer, and constructed many canals, bridges, harbours, etc. He died in 1819, after a long and useful life of eighty-three years.

## ANIMAL LIFE.

*** *The following Glossary of Scientific Terms should be mastered by the pupil before reading the Lesson. This and similar Glossaries at the commencement of some of the Reading Lessons are intended as models; after which the list of words given in the Exercises on Meanings and Derivation at the end of others should be prepared by the pupils with the aid of an Etymological Dictionary, or by the master, if the pupil be not sufficiently advanced.*

### Glossary of Scientific Terms, &c.

**ra′-di-a-ted**..*formed with rays or arms like rays proceeding from a common centre, like the star-fish.* [Lat. RADIUS, a ray or spoke of a wheel.]

**ner′-vous sys′-tem**.....*a term applied in anatomy to the brain, spinal cord, and nerves taken collectively.* [Lat. NERVUS, a nerve or sinew. Gr. SYSTEMA, an orderly arrangement.]

**di-gest′-ive or′-gan**.........*the stomach, so called because food is digested or softened and dissolved therein, and rendered fit to be taken into the blood.* [Lat. DIGERO, I arrange. Gr. ORGANON, a means of operation, or by which anything may be done.]

**ni′-tro-gen**...*a gas which is so called from entering largely into the composition of nitre. It forms nearly four-fifths of the air.* [Gr. NITRON, nitre; GENNAO, I generate or produce.]

**com-po′-nents**.........*parts or substances of which anything is formed.* [Lat. CON, together; PONO, I place.]

**fun′-gi**.........*mushrooms, toadstools, &c.;* so called from their spongy growth and appearance. [Gr. SPONGOS, a sponge.]

**cru′-ci-form**......*shaped like a cross. The radish, cabbage, &c., are called cruciform plants, as their flowers contain four petals arranged like the arms of a cross. All plants which possess cruciform blossoms are fit for food.* [Lat. CRUX, a cross; FORMA, shape.]

**ca-fe′-ine**...*the active principle of coffee, consisting of a bitter substance which readily crystalises.* [Fr. CAFÉ, coffee.]

**re-spi-ra′-tion**.......*the act of breathing out or sending out the breath.* [Lat. RE, back; SPIRO, I breathe.]

**fric′-tion**....*the act of rubbing.* [Lat. FRICO, I rub.]

**sen′-ti-ent**...........*capable of feeling or having the faculty of perception and sensation.* [Lat. SENTIO, I *feel.*]

**af-fin′-i-ties**.........*connections, mutual attractions.* [Lat. AD, to; FINIS, a border or limit.]

**am-mon-i′-a-cal**....*containing ammonia, a pungent alkali, so called because it was at first obtained near the temple of Jupiter Ammon in Egypt.* [Lat. AMMON, a name of the heathen god Jupiter.]

**sul-phu-ret′-ic**.......*containing sulphur, a brittle yellow mineral.* [Lat. SULFUR, brimstone.]

**ther-mom′-e-ter**....*an instrument used to measure heat and cold.* [Gr. THERME, heat; METRON, a measure.]

**cu′-ti-cle**.........*the outer skin.* [Lat. CUTIS, skin.]

**car′-bu-ret-ted**.......*combined with carbon or pure charcoal.* [Lat. CARBO, coal.]

**as-sim′-i-la-ting**....*converting into a like substance*, as food by digestion is converted into the substances of which our bodies are formed. [Lat. AD, to; SIMILIS, like.]

**ab-sor′-bents**........*bodies that readily take in moisture or fluid of any kind.* [Lat. AB, from; SORBEO, I suck in.]

Living bodies are usually divided into the animal and vegetable kingdoms. It may seem at first sufficiently easy to make the distinctions between an animal and a plant; and, as long as we confine our views to the higher order of animated beings, there is no room for doubt. But when we descend in the scale to the *radiata*, or radiated animals, which present no distinct nervous system, no organs of sensation, no observable mode of communication with the external world—it then becomes necessary to inquire more accurately into the peculiar points which should decide us to arrange them under the one class or the other. Perhaps the most certain of these is the presence of a digestive organ. Cuvier mentions three other marks of distinction, which, however, are by no means so general. They are—the presence of nitrogen, as one of the chemical components of all animal bodies; the existence of a circulation; and respiration. Nitrogen does exist in all animal bodies, but some vegetables contain it, as the extensive classes of fungi and cruciform plants; and in cafeine, a principle extracted from coffee, there is actually a greater quantity of it than in most animal substances. Circulation is not found to exist in the lowest class of animals. As for respiration, the leaves of plants so exactly resemble in their action the lungs of animals, that they are now familiarly spoken of by vegetable physiologists as respiratory organs.

What life is we know not; what life does we know well. Life counteracts the laws of gravity. If the fluids of our bodies followed the natural tendency of fluids they would descend to our feet when we stood, or to our backs when we lay. The cause why they do not may be referred immediately to the action of the heart and vessels; but it is evident that they derive that power from life.

Life resists the effects of mechanical power. Friction, which will thin and wear a dead body, actually is the cause of thickening a living one. The skin on a labourer's hand is thickened and hardened to save it from the effects of a constant contact with rough and hard substances. The feet of the African, who, without any defence, walks over the burning sands, exhibit always a thickened covering; and a layer of fat, a bad conductor of heat, is found deposited between it and the sentient extremities of the nerves. Pressure, which thins inorganic matter, thickens living matter. A tight shoe produces a corn, which is nothing more than thickened cuticle. The same muscle that with ease raised a hundred pounds when alive is torn through by ten when dead. Life prevents chemical agency. The body when left to itself soon begins to putrefy; the several parts of which it is composed, no longer under the influence of a higher controlling power, yield to their chemical affinities; new combinations are formed; ammoniacal, sulphuretic, carburetted, and other gases are given off, and nothing remains but dust. This never happens during life.

Life modifies the power of heat. Beneath a tropical sun, or within the arctic circle, the temperature of the human body is found unaltered, when examined by the thermometer. Some have exposed themselves to air heated above the point at which water boils; yet a thermometer placed under the tongue stood at the usual height of about 98°; and the sailors who, under Captain Parry, wintered so near the North Pole, when examined in the same way, constantly afforded the same results.

Finally, life is the cause of the constant changes that are going forward in our bodies. From the moment that our being commences none of the materials of which we

are composed continue stationary. Foreign matter is taken in, and, by the action of what are termed assimilating functions, becomes part of our composition ; while, on the other hand, the materials of which our frame has been built up, being now unfit any longer for the performance of the necessary duties, are dissolved, as it were, into a liquid or gaseous form—conveyed by the absorbents from the place which the new matter comes to occupy, and finally expelled from the system.

## Notes.

1. Cuvier, George (Baron). Born in Switzerland, 1769; died in Paris in 1832. No man, since the great Grecian naturalist, Aristotle, has so enlarged the boundaries of human knowledge, respecting the structure of the animal creation, as Cuvier. Of unconquerable industry in heaping up materials, with profound judgment and lucid ideas of arrangement, and eloquent in the expression of his results, he is universally allowed to be the first zoologist of modern times.

2. Parry, Sir Edwd. William, an admiral in the royal navy, born at Bath in 1790, died in Germany, at Ems, in 1855, and was buried at Greenwich. He accompanied Sir James Ross in 1818, in a voyage to Baffin Bay, for the discovery of the North-west Passage, and commanded the Hecla and Griper in the year following on a similar expedition. After two other voyages on a like errand he went, in 1827, on an expedition to try to reach the North Pole, and succeeded in going as far as 82° 45′ north latitude, the highest latitude that had then been attained. He finally became lieutenant-governor of Greenwich Hospital, now the Royal Naval College.

## WHITE AND RED ANTS OF INDIA.

The white ants are more to be dreaded than the devouring element of fire. These industrious perforators will achieve wonders in a short time, and if once they get into the timbers of a building, inevitable destruction follows ; for, as they work within the timber, the mischief is done before you suspect their presence. I was one day induced to go out upon the top of a verandah at Gusserah, and no sooner

had I put my foot on the floor than the beam gave way, crumbling to atoms, and letting me down, with bricks, mortar, &c., a distance of ten feet. Fortunately, I caught hold of another beam, and broke my fall, or the consequence might have been fatal. On examination, nearly all the rafters were found to be completely hollow, the white ants having eaten their way through the whole of them. So destructive are these little depredators, that nothing is safe unless placed on small stone vessels surrounded by a trench of water, and even then care must be taken that the water is replenished before completely evaporated, or the van of the besieging army will storm the trenches, and riot on the spoils of the drawers, trunks, or boxes, as the case may be. A young gentleman having arrived at my house late one evening, the servants who brought in his trunks left the one containing his shirts, white jackets and trousers, standing on the floor of the entrance-hall all night. The next day, when opened, the most wonderful metamorphosis had been effected upon the contents; every article of clothing presenting, when held up, the appearance of old-fashioned blonde lace, being pierced with thousands of holes. Each insect working upwards had wrought out for himself (carefully avoiding breaking into his neighbour's path) a covered way to the top, so that though the garments maintained their original shape, yet there could not be found any one piece of cloth as large as a sixpence in the whole of the contents. The order in which these minute sappers and miners move is remarkable; indeed, their instinct at times almost leads one to suppose they are gifted with reason.

The smaller species, or red ants, are constant depredators on the articles of the pantry and cellar, devouring sugar, butter, bread, cheese, and pastry with unsparing voracity. The earth literally teems with them, and the utmost caution and pains are necessary to preserve viands from their destructive jaws. I have often watched their motions with surprise. Sometimes I have laid a piece of sweetmeat on a table, and have picked up an ant, and placed it upon the table also: after reconnoitring the place he has descended by one of the legs, and rapidly seeking his fellows, they

have appeared to understand his communication, and have hastily turned back, and meeting others, they also have spread the news, till at length the announcer of the tidings has returned to the table followed by a long train of his fellow citizens, who, greedily seizing as much as each could conveniently travel with, have, in a continuous line about four a-breast, descended by another leg of the table, so as not to interrupt the approach of the column advancing to the prey. In this manner the whole has been carried off, and when no more remained, the tidings have spread back to the advancing column, who, immediately retracing their steps, have sought other sources of supply. Often have I been astonished at the immense loads they will carry to their stores. I have sometimes seen a large cockroach steadily advancing perpendicularly up the wall, and upon inspection have discovered hundreds of these little provident insects all busily employed beneath the body, every leg being firmly gripped by as many as could possibly lay hold, the feelers also being used as ropes to drag the huge victim along. Every now and then some change would take place, the tired ants being relieved by others, many walking backwards as well as forwards: when arrived at the hole, and they found the cockroach too large for admission, they speedily dismembered it, and the falling wings, &c., were soon brought up again by fresh detachments, till the whole was safely stored. At such times the words of Solomon have forcibly occurred to my mind: "The ants are a people not strong, yet they prepare their meat in summer." "Go to the ant, thou sluggard, consider her ways and be wise."

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## Exercise in Meanings and Derivation.—I.

*Divide and accentuate each word as in the Glossary prefixed to the preceding lesson, and give the meaning and derivation of each.*

| | | |
|---|---|---|
| **perforators** | **maintained** | **interrupt** |
| **inevitable** | **original** | **retracing** |
| **destruction** | **sappers** | **perpendicularly** |
| **depredators** | **voracity** | **dismembered** |
| **evaporated** | **viands** | **detachments** |
| **metamorphosis** | **reconnoitring** | **occurred** |
| **avoiding** | **announcer** | **admission** |

# CHEMICAL AND MECHANICAL ACTION.

## Glossary of Scientific Terms, &c.

**le′-ver**......*a bar of wood or metal used in raising weights.* [Lat. LEVO, I raise.]

**me-chan′-i-cal**.......*performed by the aid of some contrivance to assist labour.* [Gr. MECHANE (pronounce mé-ka-ne), a machine, any artificial means.]

**fa-cil′-i-ta-ting**.......*rendering more easy.* [Lat. FACILIS, easy.]

**con-vert′-ed**....*turned, altered, changed.* [Lat. CON, with or together; VERTO, I turn.]

**sit-u-a′-tion**....*place, position.* [Lat. SITUS, a site or place.]

**brit′-tle**...*apt to break, readily broken.* [Ang.-Sax. BRYTAN, to break.]

**chem′-i-cal**.........*belonging to chemistry, effected by the agency of natural causes.* [Arabic, AL KIMIA, the black art, *i.e.* magic and witchcraft.]

**prop′-er-ties**......*peculiarities, or essential qualities.* [Lat. PROPRIUS, one's own.]

**de-com-posed′**........*separated by decay or other means into elementary constituents.* [Lat. DE, from; CON, together; PONO, I place.]

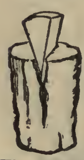
**pis′-ton**........*a short cylinder and rod attached to it, moving up and down within another cylinder in pumps, steam engines, &c.* [Lat. PINSO, I pound.]

**va′-pour**......*a gas into which most liquids and some solids are converted by heat.* [Lat. VAPOR, steam, any warm exhalation.]

**sen′-si-ble**......*that which can be felt or which is perceptible to the senses.* [Lat. SENTIO, I feel.]

**ap-pa′-rent**.....*that which may be seen, evident.* [Lat. AD, to; PAREO, I appear.]

**ex-em′-pli-fied**......*illustrated by anything selected as an example or specimen.* [Lat. EXEMPLUM, a pattern.]


The Wedge

When a heavy body is raised by a lever, when a stone is raised by pulleys, or a piece of wood split by a wedge, the nature of the substance operated on still remains the same; its position or shape only is altered. These then, are mechanical actions. The wedge is a mechanical instrument or power for facilitating labour, more especially in splitting wood asunder; but when wood is exposed to a strong heat in an iron vessel almost closed, it is converted into

charcoal, tar, vinegar, and a quantity of gases. Here there is no change in the position or form of the mass of wood, for the charcoal which remains is in the same situation, and of the same shape, and nearly of the same size as the piece of wood we used; but it is much lighter, for a great many of its particles have left it, to be turned into tar or vinegar. It is now black, whereas before it was of a whitish yellow colour; it is now brittle, whereas before it was tough and could not be easily broken; if set fire to now it will not burn with a bright yellow flame, as it would have done formerly, but with a dull red light.

This, then, is a striking example of the difference between chemical and mechanical action. When we applied mechanical action by the wedge we split the wood into pieces, differing from the original piece of wood, and from each other, in shape and size only, but exactly the same in structure and composition. But when the wood was burnt, by which a chemical action was induced, the wood was decomposed, or divided into several kinds of substance—charcoal, tar, vinegar, and gas; all differing much in their nature and properties from the original piece of wood and from each other.

In burning coal in an open fire the formation of the smoke and ashes out of a piece of solid coal is a chemical action; but the ascent of the smoke in the air—its change of position—is dependent on mechanical principles.

When we raise water by means of a pump (let us suppose the water contains iron) the piston and rod are of the same shape and composition during every part of the process, but they have frequently changed position; the water is made to change its situation, but it is of the same nature and composition when brought to the surface as when ten or twenty feet underground; above, it contains the iron as well as below. But let us apply heat and distil the water, we then separate the particles of pure water from the particles of iron with which they are associated—the water rises in vapour, the iron remains behind. Now, raising the water by the pump is a mechanical process or change; separating the iron from the pure water is a chemical process or change.

Mechanical action, then, is attended with sensible, that is to say, apparent motion, or change of position or of form. Chemical action is not necessarily accompanied with sensible or apparent motion, but is attended by a change in the nature and properties of the substances on which we operate. Chemistry, then, effects changes in the nature and properties of bodies, as exemplified in the cases of soap and glass. By the study of chemistry we learn the composition of bodies, as, that oil and soda enter into the composition of soap; and we learn how substances are made to acquire that great variety of properties by which we can apply them to so many different purposes.

## Notes.

1. Glass.—All kinds of glass are hard, transparent, and brittle, and are formed by the fusion of silicious matter, such as powdered flint or fine sand, with some alkali, alkaline earth, or salt. Thus ordinary window glass is made of sand, chalk, and soda ash, to which a large proportion of *cullet*, or old glass broken up into small pieces, is often added. The union of these materials is effected by intense heat.

2. Lever, &c.—For an explanation of the principles of the mechanical powers — the lever, wheel and axle, pulley, inclined plane, wedge and screw, see Heywood's "Class Book of Modern Science," lessons 10–14.

3. Soap.—This substance is a soluble salt formed by the union of a fatty acid with an alkali. If oil and water, with some caustic soda or potash, be boiled together, a soapy fluid will be obtained, in which a peculiar curdling is produced by the addition of a strong solution of common salt. This curd, which rises to the surface if the mixture be allowed to stand, is the fatty acid of the oil in combination with the alkali soda, or potash, as may have been used. When pressed and dried it presents all the properties of the ordinary soap of commerce. The process described is the principle on which all kinds of soap are made.

## Exercise in Dictation—I.

The hydrostatic paradox is founded on the principle that a given quantity of water may exert a power two or three hundred times less or greater, according to the manner in which it is employed.

## COALS AND COAL FIRES.

The laws which govern the constitution and states of matter are universal, and may be taught from the common operations of the arts and domestic economy, as well as from the more extended operations of nature. There is not a single instrument, or its use, which will not teach some philosophical fact; and there is no process so mean, but may be made subservient to the explanation of some branch of science. Improvements in manufactures and in the arts generally follow the progress of science. The benefits of science are universal, and the discoveries of philosophy must produce an improvement in the condition of every class of the people. There was a period when the arts, not being founded upon a knowledge of the laws of matter, which are now discovered, and not being made as perpetual as the duration of time shall admit by the art of printing, were liable to be lost by political revolutions. But in the present day almost all processes, and the construction of almost every instrument, are regulated by a knowledge of the laws of matter; and should any art be lost, there is some prospect of its recovery by the study of those principles upon which it is founded. The necessities of life, and the ever-varying temperature of our native country, as well as the extensive operations of our manufactures, give an exceeding value to coal, and point it out as a subject well worthy our consideration.

Coal is now universally allowed by geologists and chemists to be a vegetable substance. It is found in beds, varying in thickness, in many parts of England and Wales. A clay ironstone, from which a large portion of the iron used in this country is obtained, is usually associated with it—a circumstance of great importance, because the presence of coal upon the spot greatly facilitates the process of smelting. Coal consists of carbon and bitumen. The varieties depend on the proportions of these two ingredients.

"Few people are aware," says Dr. Buckland, "of the remote and wonderful events in the economy of our planet, and of the complicated applications of human industry and science, which are involved in the production of the coal

that supplies with fuel the metropolis of England. The most early stage to which we can carry back its origin was among the swamps and forests of the primeval earth, where it flourished in the form of gigantic trees. From their native bed these were torn away by the storms and inundations of a hot and humid climate, and transported into some adjacent lake, or estuary, or sea. Here they floated on the waters until they sank saturated to the bottom, and, being buried in the detritus of adjacent lands, became transferred to a new estate among the members of the mineral kingdom. A long interment followed, during which a course of chemical changes, and new combinations of their vegetable elements, have converted them to the mineral condition of coal. By the elevating force of subterranean fires, these beds of coal have been uplifted from beneath the waters to a new position in the hills and mountains, where they are accessible to the industry of man."

This information is deduced from the composition of coal, and the situations in which the beds are found. The vegetable matter of which it is formed must have been deposited in a horizontal position; but by the agency of some most violent causes, the beds have been upheaved, and, instead of being buried at a considerable depth under a long series of rocks, it is found on the surface. In all these phenomena we trace the hand of a wise and benevolent Creator, who so directed the influence of his physical agents, as to secure the comfort and happiness of His intelligent creature man. Coal has been long used for fuel in this country. In the year 1235, the burgesses of Newcastle received a royal license to dig coal and stones in the common soil. In 1306, its use was so common in London that the Parliament complained to the king of the infected state of the air produced by the general burning of coal, and proclamations were issued to prohibit its further use! These restrictions were either not attended to or soon after withdrawn; for, at the coronation of Edward III., a debt of ten shillings was incurred for coal-fires. Harrison, speaking of the coal trade, says: "It beginneth now to grow from the forge to the kitchen and hall, as

may appear already in most cities and towns that lie about the coast, where they have little other fuel, except it be turf or hassock." In 1590, coals were sold in London at nine shillings a chaldron; and it is stated in a work called "English Grievances Discovered," that in 1655 the average price was above twenty shillings per chaldron.

It has been sometimes stated that if the consumption of coal continues to increase as it has done of late, this valuable mineral must be soon exhausted. If this were to happen it would, no doubt, destroy our pre-eminence as a manufacturing people, our maritime influence would decrease, and the land now in cultivation must be again employed in the growth of wood for the purposes of fuel. These evils, however, are far distant.

In future lessons much will be said upon the composition and geological relations of coal, and its history as employed by man for fuel; but we must here proceed to speak of the manner in which it communicates heat when in combustion, that is to say, when burning.

The plan now adopted of burning coal in apartments is not unobjectionable. Smoky chimneys are, to a proverb, among the greatest nuisances of a dwelling; and, with all the care that can be taken by builders in the construction of flues, this evil cannot always be avoided. The cause of a smoky chimney is evidently the passage of the smoke down the chimney instead of upwards. Smoke, when it rises from the fire, is heated, and consequently very light; should a gust of wind happen to pass downwards as it is attempting to escape, it must of necessity give way, and pass into the room in which the fire is lighted. This is partly avoided by constructing the chimney in such a manner as to break the direct force of the descending current of air. But there are various circumstances which cause the smoke to descend instead of rising, and to detect them is not always an easy task. It has been found that the system adopted in London, of building flues back to back, is exceedingly productive of this inconvenience. Imagine that the chimneys of two contiguous apartments are carried up back to back, and that the shafts above the roof are of the same height, and let there be a fire in one

room, and not in the other ; the smoke will rise in the chimney of the one and escape ; but as cold air is always descending while the hot air is ascending, it is immediately seized by the current rushing down the next chimney, and consequently fills the room with smoke. The best means of preventing this is to carry up the flues independent of one another ; or, if this cannot be done, to build one shaft higher than the other.

This, however, is not the only, or even the worst disadvantage of the present method of heating rooms. That heated air always ascends, and cold rushes in to occupy its place, may be proved by a very simple experiment. Take a lighted candle and hold it near the crevice at the top of the door, the flame will be driven outwards ; then apply it to the bottom of the door, and it will be driven inwards. Hence it will appear that while the heated air rushes out on account of its lightness, a colder atmosphere finds its way in, and occupies its place. When the temperature of a gas or vapour is raised, it expands, becomes light, and consequently rises. The nearer we are to the ceiling of any building crowded with persons, the hotter we shall be for this reason.

Let us apply these remarks to the present system of heating our rooms, and we shall immediately discover how ill adapted the present system is to physical laws. The air, in contact with the burning coal, is heated by a positive communication of caloric to it by conduction. As soon as the temperature of the atmosphere is thus raised it expands and rises, not into the room communicating the heat it has obtained, but up the chimney, where it is soon lost, and is of no avail. All the heat we obtain from our fires, or nearly all, is that communicated by radiation. When we stand near a fire, we receive warmth by radiation ; but little, if any, heat is obtained from the process of conduction. A portion of the air heated by the fire escapes, no doubt, into the room, and ascends ; but the heat received near to the fire is from radiation, which is evident from the fact that the effect varies with the distance from the radiating body, in the same manner as light proceeding from a candle, or any other luminous substance, affects an

observer more or less, according to his distance from the object.

Some stoves are made with polished steel cheeks, or sides, which have an advantage independent of appearance, for they reflect heat, and thus increase the temperature of the apartment, while a rough black iron stove absorbs it.

As a point of economy, and consequently worthy the attention of all our readers, it may be mentioned that the constant stirring of a fire expends the fuel without any adequate advantage. There is some coal which requires this, but it is of bad quality. If the coal be good, it is better to place a quantity upon the fire and leave it to burn out, than to put a little on frequently ; for more heat is obtained, and less coal is expended.

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## Exercise in Meanings and Derivation—II.

*Divide and accentuate each word, and give its meaning and derivation.*

| | | |
|---|---|---|
| **economy** | **subterranean** | **combustion** |
| **subservient** | **accessible** | **nuisances** |
| **construction** | **deduced** | **experiment** |
| **smelting** | **horizontal** | **expands** |
| **carbon** | **phenomena** | **caloric** |
| **bitumen** | **physical** | **radiation** |
| **ingredients** | **infected** | **conduction** |
| **humid** | **consumption** | **luminous** |
| **saturated** | **pre-eminence** | **reflect** |
| **detritus** | **maritime** | **adequate** |
| **adjacent** | **geological** | **expended** |

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## Notes.

1. Absorption.—The power which is possessed by some bodies of imbibing or taking in heat, and retaining it until they part with it again by radiation. All dull, dark bodies and rough surfaces which radiate heat freely are also good absorbers.

2. Caloric.—The term applied to that property of matter, natural force, or form of motion by which the sensation of warmth is produced. Nothing is known of its real nature.

3. Combustion.—The disengagement of heat and light

which accompanies chemical combination. The elements which enter into the process of ordinary combustion are chiefly carbon, hydrogen, and oxygen. By heat the carbon and hydrogen of the fuel separate, and then chemically combine with the oxygen of the air. Combustion liberates latent heat from the fuel and the air, and makes it sensible. Latent heat is present in everything, but lies hidden as it were until its presence is made perceptible by combustion, friction, or percussion.

4. CONDUCTION. — The free and ready transmission of heat through any substance. Some bodies, such as silver and other metals, allow heat to pass freely through them from any warm body to one that is colder, and are called conductors of heat; but wood, fur, wool, cotton, &c., conduct heat very imperfectly, and are called non-conductors. All bodies that reflect heat freely are good conductors; while all bodies which are good absorbers and radiators of heat are bad conductors.

5. RADIATION.—The emission of heat from any warmer body to the colder ones around it. All dull, dark bodies and rough surfaces which absorb or suck in heat most readily have the greatest powers of radiation.

6. REFLECTION. — Light or heat is said to be reflected when it is thrown off or bent back again from the surface of the body on which it falls. All bright, light, smooth, and polished surfaces which are bad radiators of heat or light are good reflectors.

7. SMELTING. — The extraction of metals from their ores by roasting and calcination. The ore is first broken into small pieces, and then subjected to the action of intense heat in a furnace, coal, charcoal, and other substances being added in order to facilitate the operation.

**⁂ Ample information on all the above subjects except the last is given in John Heywood's "Class Book of Modern Science."**

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## PUMPS: THEIR PRINCIPLES OF CONSTRUCTION.

### GLOSSARY OF SCIENTIFIC TERMS, &c.

**im-mersed′**.........*plunged or dipped into.* [Lat. IN, into; MERGO, I plunge or dip.]

**de-lin′-e-a-ted**......*drawn or figured by lines represented by a sketch or figure.* [Lat. DE, down; LINEA, a line.]

**suc′-tion**....*the act of sucking or drawing any fluid by exhaustion of the air.* [Ang.-Sax. SUCAN, to suck.]

**at′-mos-phere**.........*the air which surrounds the earth like a shell or sphere-like*

*covering.* [Gr. ATMOS, air; SPHAIRA, a sphere or globe.]

**valve**........*the cover to an opening which opens in one direction, but not in the other.* [Lat. VALVÆ, folding doors.]

**vac′-u-um**.....*an empty space, formed by the exhaustion of the air or the withdrawal of any fluid.* [Lat. VACUUS, empty.]

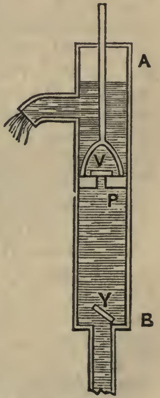
**res′-er-voir**......*a place where anything, especially water, is kept in store for use.* [Lat. RE, back; SERVO, I keep.]

**mus′-cu-lar**.......*belonging to the muscles.* [Lat. MUSCULUS, a little mouse, from the mouse-like swelling of the muscle on contraction below the skin.]

**sy′-ringe**........*a tube with a piston, by which fluids are taken up and thrown out again.* [Gr. SYRINGX, a reed or pipe.]

**al-ter′-nate**......*first one and then the other, by turns.* [Lat. ALTERNO, I do anything by turns, from ALTER, the other.]

The common pump is constructed on this principle. By the act of pumping, the pressure of the atmosphere is taken off one part of the surface of the water; this part, therefore, rises, being forced up by the pressure communicated to it by that part of the water on the surface of which the weight of the atmosphere continues to act. The body of a pump consists of a large tube or pipe, whose lower end is immersed in the water which it is designed to raise. A kind of stopper, called a piston, is fitted to the tube, and is made to slide up and down it, by means of a metallic rod fastened to the centre of the piston.



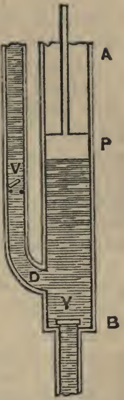
Common Pump.

The various parts of a pump are here delineated. A B is the pipe or body of the pump; P the piston; V a valve, or little door in the piston, which, opening upwards, admits the water to rise through it, but prevents its returning; and Y a similar valve in the body of the pump. When the pump is in a state of inaction, the two valves are closed by their own weight; but when, by drawing down the handle of the pump, the piston ascends, it raises a column of air which rested

upon it, and produces a vacuum between the piston and the lower valve, Y; the air beneath this valve, which is immediately over the surface of the water, consequently expands, and forces its way through it; the water, then, relieved from the pressure of the air, ascends into the pump. A few strokes of the handle totally exclude the air from the body of the pump, and fill it with water, which, having passed through both the valves, flows out at the spout. Thus the air and the water successively rise in the pump, on the same principle that the mercury rises in the barometer. Water is said to be drawn up into a pump by suction; but the power of the suction is no other than that of producing a vacuum over one part of the liquid, into which vacuum the liquid is forced by the pressure of the atmosphere on another part. The action of sucking through a straw consists in drawing in and confining the breath so as to produce a vacuum, or at least to lessen materially the quantity of air in the mouth; in consequence of which the air within the straw rushes into the mouth, and is followed by the liquid, into which the lower end of the straw is immersed. The principle is the same, and the only difference consists in the mode of producing the vacuum. In suction, the muscular powers answer the purpose of the piston and valves. The distance from the level of the water in the well to the valve in the piston ought not to exceed thirty-two feet, otherwise the water would not be sure to rise through that valve, for the weight of the air is sometimes not sufficient to raise a column of mercury more than twenty-eight inches, or a column of water much more than thirty-two feet; but when once it has passed that opening it is no longer the pressure of air on the reservoir which makes it ascend—it is raised by lifting it up as you would raise it in a bucket, of which the piston formed the bottom. This common pump is, therefore, called the sucking and lifting pump, and is constructed on both these principles.

The forcing pump consists of a forcing power added to the sucking part of the pump. This additional power is exactly on the principle of the *syringe*. By raising the

piston the water is drawn up into the pump, and by making it descend it is forced out. The large pipe A B represents the sucking part of the pump, which differs from the lifting pump only in its piston, P, being unfurnished with a valve, in consequence of which the water cannot rise above it. When, therefore, the piston descends it shuts the valve Y, and forces the water, which has no other vent, into the pipe D. This pipe is likewise furnished with a valve V, which, opening outwards, admits the water, but prevents its return. The water is thus first raised in the pump and then forced into the pipe, by the *alternate* ascending and descending motion of the piston, after a few strokes of the handle to fill the pipe, from whence the water issues at the spout.



Forcing Pump.

## BOTANY AND ITS USES.

What is botany? is a question, doubtless, that is often asked by many, and this inquiry is as frequently followed by another—What is the use of it? To these queries it may be answered that botany is the science that treats of the arrangement and the classification of plants, and all members of the vegetable kingdom; as, zoology and mineralogy treat of the arrangement and classification respectively of animals or members of the animal kingdom, and stones and metals, or members of the mineral kingdom. One of its chief uses is to enable us to distinguish between plants that are fit for food and plants that are hurtful. Thus, for example, no plant whose blossom or flower consists of four leaves or petals, arranged in the form of a cross, is poisonous; and, therefore, all cruciferous plants, as they are called from the cross-like form of their flowers, may be used for food. Among plants of this order are cabbages, radishes, turnips, and many of our most wholesome vegetables. On the other hand

the deadly nightshade, a plant frequently found in the hedges of this country, bears berries that are poisonous in the extreme, and therefore to be carefully avoided. This plant is easily recognised by its blossom, which consists of a yellow spike-like centre surrounded by purple petals. The *fruit* of plants bearing a similar blossom are to be avoided. Some may urge that the potato belongs to this class of plants, and so it does; but although the *tuber* or root of the potato forms one of the most valuable articles of vegetable food that we possess, no one would think of eating the potato-apple, or fruit of the potato, in which the seed is found, and which is of an injurious character.

It is often a matter of astonishment to those who are acquainted with the nature of plants—a knowledge derived less from actual experience than the study of botany—to see the carelessness with which people in passing along gather and bite the leaves or flowers of plants, with the properties of which they are unacquainted. Children, too, are often permitted to gather and play with flowers, seeds, or berries, which may prove very pernicious. And again, it is no uncommon thing for very ignorant people indiscriminately to advise and to adopt for the cure of diseases, plants or roots, of whose medical properties and powers they have very little idea.

We frequently read cases in the newspapers of deaths resulting from eating poisonous plants, and from among them the following, which happened in 1833, may be cited, as being one of the most striking, owing to the vocation of the sufferer and the medical knowledge to which he laid claim:—

"William Ross, of Macgillandris, a small farmer in the vicinity of Tain, died suddenly from having eaten the root of the plant commonly called monkshood, or wolfsbane, which is known to botanists as the *Aconitum napellus*. Ross was for many years a gardener, and had, or pretended to have, considerable skill in treating several diseases by the administration of herbs. His daughter had got a root of monkshood in a neighbouring garden, and brought it to her father. He mistook it for some other plant, and began chewing it, when in a very short time he was taken ill. A doctor was sent for, but ere he arrived it was too late; the

unfortunate man lingered an hour or two, and then died." This plant has a handsome flower, and is much cultivated in gardens, perhaps much more than it ought to be, or would be, if its deleterious properties were more generally known. The following description of the plant is given by way of caution, especially against its being admitted into play-grounds and gardens frequented by children.

The monkshood or wolfsbane rises with a single erect stalk from two to six feet high, beset with many leaves, of a dark green colour above, but underneath of a whitish cast. The leaves are large, deeply cut, and have long foot-stalks. The flowers grow in a long, pyramidical spike or row, consisting of many florets. Each flower resembles the form of a helmet or hood, from which it takes its name. The colour is a deep purple or violet.

This plant is a native of the mountainous and woody parts of France, Germany, and Switzerland. Every part of it is poisonous, especially when fresh. It loses some of its virulence by being transplanted into our soil. The above fact, however, among many others, proves that it is still highly dangerous. When chewed, it imparts first an acrid taste and pinching sensation to the tongue, but afterwards produces insensibility, a remarkable debility of the limbs, convulsive motions of the face, vomiting, delirium, and death. If applied to a wound, its effects on the nervous system are instantaneous and most alarming. Even by holding it long in the hand very frightful and even fatal effects have been produced.

The effects of this plant were tried by way of experiment on four condemned criminals on the continent; two of them perished, and two were with great difficulty saved.

A person having eaten some of the leaves was sent into a state of raving madness. The surgeon who was called to his assistance declared that it was not occasioned by the plant; and to convince the company of its harmlessness, he himself ate freely of the leaves in their presence: but he suffered for his temerity, for he soon after died in great agony.

The following advertisement was some years since circulated in a city where fatal accidents had occurred. The precautions suggested ought to be universally adopted:

"Gardeners are particularly desired to take care never to throw poisonous plants out of gardens into the streets, lanes, or even fields, to which people can have access. Poor children, for diversion, curiosity, or hunger, are prompted to eat all kinds of vegetables which come in their way, especially seeds, fruits, or roots. This caution does not proceed from fanciful speculation, but from actual mischief produced by the cause here specified. A physician has lately seen several children poisoned with the roots of aconite or monkshood, thrown into an open field in the city of Chester, and with the seeds of stramonium or thorn apple, thrown into the street. The former were seized with very violent complaints of vomiting; an alarming pain of the head, stomach, and bowels; the latter with blindness, and a kind of madness, biting, scratching, shrieking, laughing, and crying, in a frightful manner. Many of them were very dangerously affected, and escaped very narrowly with life. These, and all other poisonous plants taken out of gardens, should be carefully buried or burned."

It is hoped that the above anecdotes will lead many youthful readers to the study of botany, which is the science that teaches us the classification, nature, and properties of plants. To attempt to give even an outline of the classification is impossible here; but for the guidance of those who wish to become acquainted with this most interesting and desirable science, Lindley's *Vegetable Kingdom* and *School Botany* and Bentley's *Manual of Botany* may be indicated as useful elementary works on the subject.

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## Exercise in Meanings and Derivation.—III.

*Divide and accentuate each word, and give its meaning and derivation.*

| | | |
|---|---|---|
| **botany** | **pernicious** | **transplanted** |
| **classification** | **indiscriminately** | **acrid** |
| **zoology** | **neighbouring** | **debility** |
| **mineralogy** | **chewing** | **convulsive** |
| **distinguish** | **deleterious** | **delirium** |
| **petals** | **caution** | **temerity** |
| **cruciferous** | **frequented** | **circulated** |
| **injurious** | **pyramidical** | **precautions** |
| **character** | **virulence** | **speculation** |
| **derived** | **classification** | **elementary** |

## Exercise in Dictation—II.

A sword made of steel, the original metal of which was not worth a shilling, is sometimes sold for 300 guineas; and a watch chain has produced fifty guineas, the metal of which, before it was wrought, was not worth threepence. In like manner, a yard of Mechlin lace will fetch twenty guineas, the flax in which it originally was not being worth threepence; so a single painting, not two yards square, has been valued at £25,000, and a shawl, which contains but a few ounces of wool, frequently sells for sixty or eighty guineas.

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# THE MATERIALS OF NATURE.

### Glossary of Scientific Terms, &c.

**va-ri′-e-ty**......*difference.* [Lat. VARIUS, different.]

**di-ver′-si-fied**.......*differently made or formed.* [Lat. DIS, apart or aside; VERTO, I turn.]

**ma-te′-ri-als**... .....*substances from which anything is made.* [Lat. MATER, the mother or producer.]

**in-an′-i-mate**......*without life.* [Lat. IN, not; ANIMA, life.]

**struc′-ture**....*arrangements of parts or materials.* [Lat. STRUO, I build; participle, STRUCTUS, built.]

**com-bi-na′-tions** ..*unions of materials forming new compounds.* [Lat. COMBINO, I join together; from CON, together, and BINI, two by two.]

**in′-fi-nite**.........*without end or limit.* [Lat. IN, not; FINIS, an end.]

**con′-tem-plate**......*to consider attentively with deep thought.* [Lat. CONTEMPLOR, I mark out a place for observation; TEMPLUM, the Latin word for "temple," meaning a place cut off and set apart for any special purpose, religious or otherwise.]

**di′-a-mond**...*the most valuable and the hardest of all precious stones.* [Gr. ADAMAS, a stone so hard that it cannot be broken.]

**trans-pa′-rent**....*so clear that objects may be seen through it.* [Lat. TRANS, through; PAREO, I appear.]

**re-splen′-dent**...*shining with great brilliancy.* [Lat. RE, intensive particle; SPLENDEO, I shine.]

**ex-is′-tence** ..*state of living or being.* [Lat. EX, out; SISTO, I stand.]

**cor-ro′-sive**...*having the power of eating away.* [Lat. COR, intensive particle; RODO, I gnaw; participle, ROSUS, gnawed.]

**im-pressed′**....*deeply fixed or implanted as if by pressure.* [Lat. IN, into; PREMO, participle PRESSUS, I press.]

**ox′-y-gen**...*a gas existing in air, water, &c., which supports animal life and combustion, so called from its connection with acids.* [Gr. OXUS, acid; GENNAO, I produce.]

**in-tox′-i-ca-ting**.......*causing drunkenness or madness as by a drug or alcohol.* [Gr. TOXICON, a poison in which arrows were dipped.]

**a-qua-for′-tis**.......*nitric acid.* [Lat. AQUA, water; FORTIS, strong.]

**o-paque**...*that which will not admit of the passage of light, or which cannot be seen through.* [Lat. OPACUS, dark, shady.]

**ul′-cer**...*a dangerous sore discharging matter.* [Lat. ULCUS, a wound.]

**ex-cru′-ci-a-ting**...*causing intense pain and agony.* [Lat. EX, from or out; CRUCIO, I crucify, or torture by exposure on a cross.]

**e-lec-tric′-i-ty**.....*the property of attraction and repulsion of light bodies, so called because it was first observed in amber.* [Gr. ELECTRON, amber.]

When we look abroad on the world around us, one of the first things that strikes us is the variety in the objects that present themselves to our notice. The endless variety of forms and appearances which animals, vegetables, and other kinds of bodies present, would seem to render it almost a hopeless task to acquire a knowledge of the different substances of which they are composed; but it fortunately happens that all the diversified works of nature are made up of a few simple materials; that we do not need, in studying every different kind of animal or vegetable, every different air or liquid, every kind of rock or mineral, to learn the properties of a new and different substance for each. There are many thousand kinds of stones and minerals, and other inanimate substances; there is no end to the variety of animals; there are more than sixty thousand different kinds of plants known; but, however different they may be from each other in structure or appearance, they are made up of combinations, as they are called, of a few simple substances, not above sixty-four in number, of which chemistry has discovered this endless variety to be composed. It may seem surprising that

objects so very opposite to each other in every respect should be composed of similar materials; but, if we reflect on the various forms of building which man can construct out of a few bricks, or on the infinite variety of words, even in one language, which are made up of the letters of the alphabet, we shall not wonder at the varied forms into which Nature throws her simple materials. This is placed in a more striking light when we contemplate the different forms which even the same substance can assume. To select one of the many examples of which there are of this: the diamond, the rarest, the hardest, most transparent, and most resplendent mineral known, consists of exactly the same material as the dull, opaque, black, earthy substance called charcoal. When burnt, it produces the same matter as when charcoal is burnt; and both produce the same substance, namely steel, when they are made to unite with iron. To take yet another example of the wonderful powers which have been impressed upon matter, let us look at the compounds of two gases, oxygen and nitrogen. These two thin, transparent, and invisible bodies, united in certain proportions, constitute the air which we breathe and are perpetually in contact with, upon which our existence depends, and of which we take in a supply about a thousand times every hour. The same materials, in different proportions, form the intoxicating gas which produces such peculiar effects when inspired. The same ingredients, in other proportions, form a curious gas, transparent and colourless, which, whenever it meets the air, also transparent and colourless, becomes of a dark red colour, by depriving the air of that part of it which we use in breathing. The beautiful red fumes thus formed are composed of the same two gases. Lastly, the same substances, with a little water added, are the ingredients of aquafortis, one of the most virulent and corrosive poisons known, which instantly corrodes the skin and produces a deep ulcer when applied to it, and would cause the most excruciating torture and sudden death if it could be taken internally. By subjecting atmospheric air to the influence of electricity, it has actually been converted into aquafortis. Let us pause for a moment to reflect on the wonders which

a knowledge of nature unfolds to us. Electricity is constantly present in the earth and atmosphere, and it can convert the atmosphere into a deadly poison. Here, then, we are surrounded on all sides by the elements of destruction. Yet this substance, the air, and this singular agent, electricity, which, by a slight change in their mutual relations, might destroy us in an instant, are constantly, and in a thousand ways, contributing to our support and well-being. So true it is that we are fearfully and wonderfully made.

## Notes.

1. ELECTRICITY, the name of the science which treats of what is called the electric fluid, and which investigates the phenomena and laws of the properties which this fluid possesses. The electric fluid is supposed to exist in every body in nature, but in very unequal proportions; and it is believed that it has a tendency to equalise itself, whence many most important results arise. Thus, if two clouds charged with unequal quantities of electricity come near each other, a portion of the fluid passes from the one which has the most to the one which has the least, and the transfer is accompanied with a bright flash and a report, usually termed lightning and thunder. For much useful information on electricity, see John Heywood's "Class Book of Modern Science," Chapter IX, on Atmospheric Electricity.

2. ELEMENTARY BODIES.—A list of the sixty-four elementary bodies, of which all other bodies are compounded, and on which the whole fabric of the science of chemistry is based, will be found in John Heywood's "Class Book of Modern Science," Chapter X, on Chemistry.

## MAN CONTEMPLATED.

Let us occupy a few minutes in considering the structure of man, whose existence, as we all know, can be traced to a beginning. Let us examine him, body and mind. First, as to his body—it is full of contrivances—full of the evident results of the most profound science and of the nicest art. How perfectly, for example, is the structure of his eye

fitted for the reception of those rays of light which are falling upon it in all directions from visible objects ! How nicely are the rays refracted by its several lenses ! How easily do they glide through the pupil ! How comprehensive, yet how perfect, is the picture formed on its retina—a picture reversed to inspection from without, but all in upright order to the percipient within ! Here, indeed, is the science of optics displayed in its perfection. Then turn to his ear. How finely does it illustrate the principles of acoustics ! How nicely are its cavities fitted for the reception and increase of sound ! How accurately does the drum in the centre respond to the undulation from without !

Look at that most convenient of levers—my brother's arm ; with what ease does he apply its forces ! How nicely are its elbow and its shoulder adjusted for their respective purposes ; and how admirably is the whole completed by the addition of a hand ! Think of the union of strength and pliancy which distinguishes his spine—an effect produced by machinery of the most elaborate description ! Contemplate his joints—the hinge where a hinge is wanted—the ball and socket where his comfort demands that peculiar structure ; all lubricated by ever-flowing oil ; all working with a faultless accuracy ! Think of his muscles, endued with that curious faculty of contraction by which he is enabled to move his members ! Think of the studied mechanical adjustment by which, without ever interrupting each other's functions, these muscles pull against each other and keep his body even ! Then turn your attention to his blood ; a fluid in perpetual motion—supplied with pure air in one stage of its journey, and, in another, with the essence of his food ; and conveying the elements of life every few moments to every part of his body ; driven from the heart by one set of vessels and restored to it by another ; those vessels most artificially supplied with valves to prevent the backward motion of the fluid ; while the pump in the centre is for ever at work, and makes a hundred thousand strokes in a day, without even growing weary ! I will not now dwell particularly on the still more complicated structure of his nerves, on the chemistry of his stomach, on the packing of the whole machinery, on

the cellular substance which fills up its cavities, on the skin which covers it, on the sightliness and manly beauty which adorn the fabric. I will rather turn to the mind, which does, indeed, complete the man—its subtle powers of thought, memory, association, imagination—its passions and affections—its natural and moral capacities. Surely we must all acknowledge that man is a wonderful creature indeed—an effect for which it is utterly impossible to imagine any adequate cause but the contriving intelligence and irresistible power of an all-wise Creator.

We all know that a man has a father—a grandfather—that he looks back on an indefinite series of progenitors. This fact only strengthens my case. Certain it is that his own structure, both of mind and body, contains numerous and unquestionable proofs of design. Where there is a design there must, of necessity, be a designer. The parent, as we are all perfectly aware, is not that designer. Our understanding can find no rest in the mere medium of production. We are compelled to have recourse to an unseen and superior power, and to confess that the designer is God. But if the workmanship displayed in the formation of the individual proclaims the wisdom and power of God, still more conspicuously are they manifested in a succession of generations—in the wondrous capacity bestowed on every kind of living creature to produce and reproduce from generation to generation its own likeness.

Were it possible that a series of successive finite beings should exist from eternity (a notion which, in my opinion, disproves itself), and, supposing it to be possible, were it probable, or even certain, that mankind have so existed—our argument from a design to a designer would still remain untouched. It would continue to apply with resistless force to every individual of the species, and this it is impossible to contradict.

But it so happens that we are able to trace not only every individual man, but our whole race to an undoubted beginning. That beginning, which took place about six thousand years ago, is plainly recorded in Scripture, at the beginning of the book Genesis, and the record is supported by the conclusions of science.

## Exercise in Meanings and Derivation.—IV.

*Divide and accentuate each word, and give its meaning and derivation.*

| | | |
|---|---|---|
| **contrivances** | **cavities** | **association** |
| **reception** | **accurately** | **memory** |
| **refracted** | **undulation** | **imagination** |
| **comprehensive** | **adjusted** | **adequate** |
| **retina** | **lubricated** | **irresistible** |
| **reversed** | **contraction** | **progenitors** |
| **inspection** | **perpetual** | **designer** |
| **percipient** | **artificially** | **individual** |
| **optics** | **complicated** | **capacity** |
| **displayed** | **cellular** | **conclusions** |
| **acoustics** | **subtle** | **beginning** |

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## THE CANDLE AND COMBUSTION.

### PART I.

### GLOSSARY OF SCIENTIFIC TERMS, &c.

**sim-ul-ta′-ne-ous-ly**...*exactly at the same time.* [Lat. SIMUL, at once or at the same time.]

**ex-per′-i-ment**...*trial, essay, search by trial.* [Lat. EXPERIOR, I make trial of.]

**ig-ni′-ted**...*set ablaze, kindled.* [Lat. IGNIS, fire.]

**viv′-id**...*very bright, possessing great brilliancy.* [Lat. VIVO, I live.]

**ox′-ide**...*a compound of oxygen and a base destitute of acid: thus rust is red oxide of iron produced by the combination of the oxygen of the air with the iron.* [Gr. OXUS, acid.]

**bro′-mine**...*an elementary substance, of a dark red colour and of a disagreeable suffocating smell.* [Gr. BRŌMOS, a fetid smell.]

**phe-nom′-en-a**......*remarkable appearance*, of any kind. [Gr. PHAINO, I show or make to appear.]

**chlo′-rine**..*a gas of a pale green colour, and possessing a disagreeable smell.* [Gr. CHLŌROS, pale green.]

**i′-o-dine**...*an elementary body, so called from the violet colour of its vapour. It is present in large quantities in sea weed.* [Gr. ION, a violet; EIDOS, appearance.]

**den′-si-ty**...*the proportion of mass to volume: thus one body is said to have greater density than another, when, equal volumes being taken, the weight of the one is greater than that of the other.* [Lat. DENSUS, thick.]

**phos′-phor-us**......*a yellowish wax-like substance, highly inflammable, and emitting light and luminous fumes in the dark.* [Gr. PHŌS, light; PHERO, I bring.]

**ba-ry′-tes**...*an earth so called on account of its great weight.* [Gr. BARŪS, heavy.]

**stron′-ti-an**...*an alkaline earth first found in the lead mines of Strontian, in Argyleshire, whence its name.*

**con′-tact**...*close touching, meeting.* [Lat. CON, together; TANGO, I touch.]

**in-sert′-ed**...*put into or among.* [Lat IN, into; SERO, I join; participle SERTUS, joined.]

**con-sump′-tion**....*destruction in any way, as by fire, eating, wasting, &c.* [Lat. CONSUMO, I destroy; from CON, meaning completely; SUMO, I take.]

**im-bibed′**......*taken into as by suction.* [Lat. IN, into; BIBO, I drink.]

**e-con′-o-my**...*management or arrangement; in the present case, of nature.* [Gr. OIKOS, a house; NOMOS, a law or prescribed rule.]

**cur-vi-lin′-e-ar**......*having a curved form, or bounded by curved lines.* [Lat. CURVUS, bent out of a straight line; LINEA, a line.]

The candle is a most important invention, and an interesting object of study, whether we consider its construction as an art or its use in supplying light after the great orb of day ceases to illuminate our hemisphere. It is not, however, intended here to describe at present the process by which candles are manufactured, but the means by which they afford light.

When any substance gives out heat and light simultaneously, and suffers at the same time a chemical change in its constitution, it is said to be in a state of combustion. This definition may appear difficult to be understood, but may be easily illustrated, and will assist us in our future explanations. Coal and wood, when burnt in the open air, give out heat and light, and are then said to be in combustion. There are many substances which can never be placed in this condition, although exposed to a very high temperature; and there are other substances, such as the metals, which are not seen in a state of combustion under ordinary circumstances, and yet are really combustible substances.

The following simple but beautiful experiment will prove the truth of this assertion. Take a small iron wire,

and twist it into the form of a corkscrew. Then take a glass jar, open at the bottom end, having a cork at the top, and put the wire through the cork, and fill the jar with oxygen gas. Then raise the ~~temperature~~ of the wire till it is red hot, or place on its end an ignited piece of wood dipped in tallow, and plunge the wire into the gas. It will immediately suffer combustion, throwing out vivid sparks in all directions. The oxygen combines with the iron, forming an oxide of iron.

Now, when a substance burns in the atmospheric air it combines with the oxygen, and without a supply of that gas there can be no combustion. It was supposed by Lavoisier and others of the old chemists, from observing the phenomena of combustion in the air, that whenever oxygen unites with any body combustion is produced. This, however, is not the case, for the rust on iron or steel is produced without combustion, and yet it is occasioned by the combination of iron and oxygen.

Those substances which are necessary for combustion, and yet are not combustible, are called supporters. They are four in number, and are all simple substances—oxygen, chlorine, iodine, and bromine. Sulphur and phosphorus occasionally act the part of supporters. When sulphur, in a liquid state, is made to combine rapidly with copper, or zinc, or iron, and perhaps also with some other bodies, it becomes solid at the instant of union, and the new compound becomes red hot, and exhibits all the phenomena of a short combustion. When liquid phosphorus is brought into contact with hot lime, barytes, or strontian, a rapid combination takes places, and all the phenomena of a brilliant combustion present themselves.

These remarks will, it is hoped, render our explanation of one instance of combustion, the burning of a candle, more easily understood than it could otherwise be.

A candle is composed of a cotton wick surrounded with wax or tallow. Both these are necessary, and also the contact of the atmospheric air, for the process of combustion. Let us, however, take a piece of tallow, and placing it in an iron spoon hold it over the fire. It will soon melt; and when in a fluid state, bring a lighted piece of candle

to it; but it does not burn as might be expected. Hold it again over the fire till a vapour rises from it, then bring the light again to it, and it instantly catches fire. From these experiments, therefore, it will appear that, in order to produce the combustion of wax or tallow, a heat must be given to it sufficient to convert it into a vapour, when it becomes very inflammable. The object of the wick is now evident. When the cotton is lighted it becomes red hot, and the tallow or wax of the top of the candle is melted and drawn up between the threads by what is termed the force of capillary attraction. It is then exposed to an intense heat, which vaporises, and at the same time inflames it. When the candle is blown out a disagreeable smell is produced. This is occasioned by the unburnt vapour which is escaping, and may be seen to rise from the top of the wick. If a light be brought near it instantly ignites again. The quantity of vapour formed and consumed must depend on the intensity of the heat supplied by the wick, and consequently a very fine thread of metal is sometimes inserted, and this being at a red heat causes a greater consumption of tallow, and the more perfect consumption of the vapour that is formed. The substance of which the wick is formed must be chosen according to the purpose for which the candle is to be used. The rush-light is so called because the wick is formed of a rush.

It has been already stated that atmospheric air is necessary for the support of combustion, and this may be proved by many simple experiments. Take any large glass vessel—a tumbler, if no larger could be obtained; place a piece of lighted candle under it, and fix it firmly upon the table, so that no air may enter. The flame soon grows more and more feeble, and in a short times goes out. The same thing would happen in an apartment if there were not a constant supply of fresh air entering from various crevices, the door, or the windows. A fire lighted in a close room would soon consume all the oxygen of the contained air, and would then die away. The same principle is necessary for the support of animal life. The people who died in the Black Hole at Calcutta were deprived of life from want of pure atmospheric air. The oxygen of the

atmosphere is constantly imbibed, and performs a most important duty in the animal economy. Withdraw it and death ensues. The constant supply of oxygen from the atmosphere for the support of respiration and combustion is beautifully provided for. When the temperature of air, and, indeed all vapours and gases, is raised, it expands, and consequently becomes lighter, bulk for bulk, than it was previous to its increase of heat; and in all apartments some provision should be made for its escape. The cold air, on the other hand, rushes in to occupy its place, so that on the surface of the earth we are always supplied with air of nearly the same density.

Let us now see how the air acts upon the burning candle. It surrounds the flame, and by conduction the heat is communicated to it, so that there is a constant current of hot air ascending, which urges the flame upwards, causing it to have a sharp-pointed form. It is for this reason that flame always ascends. The disposition to ascend is so strong, that even when the gas-light burners are made in the form of a star, the flame, which is intended to go downwards, takes a curvilinear form, although there is a considerable power in the gas forcing it in the downward direction.

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## Notes.

1. Black Hole of Calcutta.—A dungeon in the fort of Calcutta, about eighteen feet square, and lighted only by one small window, into which, on June 18, 1756, one hundred and forty-six British merchants and others, resident in Calcutta, were thrust by order of the nabob, Surajah Dowlah. Of these unfortunate men only twenty-three survived the horrors of the night, the remainder having died of suffocation arising from the heat and stench produced by the confinement of so many persons in so small a place in a hot country.

2. Lavoisier, Antoine Laurent, a celebrated French chemist, born in Paris, 1743, perished by the guillotine on a false charge, May 8, 1794. He made many important discoveries as to the nature of the air, and other elastic fluids or gases, and propounded a new system of chemistry in 1786, which was thought much of in France and Germany at the time.

3. Capillary Attraction.—The power possessed by small tubes of causing fluid to ascend in them by the attraction exercised by the sides of the tubes over the fluids. It is by virtue

of this kind of attraction that water will rise in flannel, the end of which touches the surface of water in a basin, or in a lump of loaf sugar, until it is completely saturated. The first word is derived from the Latin CAPILLA, a hair; while the second comes from AD, to, and TRAHO, I draw.

## Exercise in Dictation—III.

By universal tradition, Egypt is allowed to have been the cradle of the sciences; and, when reason finds in that region a concurrence of all the physical circumstances calculated for such an effect; when it finds at once in the vicinity of the tropic, a zone of heaven, equally free from the rains of the equator and the fogs of the north; when it finds there the central point of the antique sphere; a salubrious climate; an immense, yet manageable river; a land fertile without either labour or art; inundated, without pestilential exhalations; situate between two seas bordered by the shores of the richest countries: it becomes manifest that the inhabitants of the districts of the Nile, who are inclined to agriculture from the nature of their soil; to commerce, from their facility of communication; to geometry, from the annual necessity of measuring their possessions; and to astronomy, from the state of their heavens, ever open to observation, must first have passed from the savage to the social state, and consequently, must first have attained that general knowledge requisite to civilised man.

## THE CANDLE AND COMBUSTION.

### PART II.

There are many interesting experiments which will show the influence of air, or rather the oxygen of the air, as a supporter of combustion, and that the intensity of heat is increased by a liberal supply of that substance.

When a candle is blown out, the upper part of the wick, or the snuff as it is called, will frequently remain of a red heat. The heat is sufficient to melt the wax, and even to form a vapour, as may be seen, but is not sufficient to ignite it. While the wick is of a glowing heat, blow suddenly upon it, or raise it rapidly in the air, and the chances are that it will light again, for the temperature of the wick is suddenly raised.

In striking a light we have another example. A piece of

steel and a piece of flint are struck together, and the concussion is so great that small pieces of flint are knocked off red hot. These fall upon tinder prepared by a partial combustion of linen rag, to which they instantly communicate sufficient caloric to bring it to a red heat. Let us now take a match, properly dipped in sulphur, and apply the end to the heated part of tinder. The chances are that it will not be ignited; but if we blow on it, the heat is sufficiently great to cause the sulphur to inflame.

In the construction of furnaces, a good draft is an object of great importance. Bellows are used in forges, and in fires generally, because the air thus blown upon the burning material increases the heat. When a fire is very low wood may be laid upon it, but the heat is not sufficient to kindle the sticks. By the use of the bellows the coals themselves are made to kindle, and the wood is then ignited. You cannot light a candle with a dull red coal taken from the fire; but if you blow upon it, the heat becomes sufficiently great to set it on fire.

We now come to consider the constitution of the flame which is produced by the candle. If you look steadily at the candle you will perceive that the flame consists of two cones, the outer one bright and pointed, the inner one of a darker colour and with a blunt point. The vapour, which is formed all round the outside of the wick, is burnt, and produces the bright-coloured flame; but that which rises immediately above the centre of the wick, and forms the dark-coloured cone, is an unburnt vapour. To this part no air can get, and it is on that account it will not burn. The surrounding air is consumed in forming the outer flame, so that the interior vapour has no chance of being consumed. In proof that this is the case, we may examine the flame of the argand, or dining-table lamp. In this lamp the wick is a cotton ring instead of a string, and it is placed upon a circular rim of brass fitting into a cavity connected by two arms with the reservoir of oil. The level of the cotton is above the level of the reservoir, so as to prevent the oil from being thrown out of the circular cavity when being removed, and to give facility for the operation of the capillary force, of which we have already

spoken. The interior of the cavity holding the wick is thus filled with air, and each side of the cotton is exposed to a current which ensures the complete combustion of the vapour which is formed. In this flame, therefore, there is no dark spot. To increase the draft, and to secure a regular current of air, a glass is put round the flame in such a manner as to give a free access on each side of the wick, and at the same time to guard the flame from any current that may be passing through the apartment. Remove the glass for a moment, and the light will become unsteady, and of a dirty red colour. If the wick be turned too high the lamp will smoke, and the same result will be produced by preventing the access of the air to the inner side of the wick.

There are two experiments by which we may prove that the interior of the flame of a candle consists of unburnt vapour. Take a very narrow piece of cardboard about four inches long, and hold it for a few seconds just above the wick of a burning candle snuffed short. When removed it will be scorched in two places in the direction of its length, the two places in which it has come in contact with the exterior cone. In the centre it will not be in the least degree affected, for there the vapour is not in combustion.

The same fact may be proved in another way. Take a small square of glass and place it quickly over the flame of a candle, and you will see a circular rim of light, and within it a dark spot; the circular rim is the burning vapour, and the dark spot is that which is unconsumed.

There is now only one other subject to which it will be necessary to refer. Take a piece of wire gauze, and hold it in the midst of the flame of a candle or a gas light, and you instantly intercept it, and the vapour will be seen to rise above in an unconsumed state. The reason is this, The metals are good conductors of heat, and consequently carry away so much of that produced by the combustion of the candle, when used as described, as to prevent the entire consumption of the vapour. To be satisfied that there is much vapour or gas thrown off without being consumed, place a lighted paper over the wire gauze, and it will be inflamed. Sir Humphry Davy applied this principle in

the invention of his safety lamp. This lamp consists of a common burner, placed within a wire gauze frame. It is especially intended for the use of miners. In the coal pits seams are frequently opened in which there are extremely combustible gases, which in former times have caused serious losses of life and property. By using the Davy lamp these accidents are in a great measure prevented. Supposing one of these lamps to be taken into the gallery of a mine having an atmosphere of such an explosive compound, a detonation would be produced in the lamp, but the wire gauze would prevent the flame from communicating with that which fills the gallery, the explosion of which might destroy many lives and lay the whole mine in ruins.

One inconvenience was originally attached to this instrument, namely, that the safety which attended its use often induced the men to go into more deteriorated atmospheres than they otherwise could, which sometimes occasioned the lights to be extinguished. To obviate this inconvenience, Davy contrived to suspend a coil of platinum wire over the flame of each lamp ; the effect of which is that the moment the lamp is extinguished by the superabundance of carburetted hydrogen gas in the atmosphere, the coil of platinum wire becomes of an intense red heat, and this affords light enough to enable the men to find the road through the different passages to the entrance of the mine ; and as soon as the lamp is brought into a part of the mine in which the atmosphere contains less than one-fourth of carburetted hydrogen, the heated platinum of itself relights the lamp.

## Exercise in Meanings and Derivation.—V.

*Divide and accentuate each word, and give its meaning and derivation.*

| | | |
|---|---|---|
| **oxygen** | **interior** | **detonation** |
| **combustion** | **reservoir** | **deteriorated** |
| **liberal** | **capillary** | **platinum** |
| **glowing** | **current** | **carburetted** |
| **partial** | **access** | **intense** |
| **caloric** | **scorched** | **extinguished** |
| **material** | **exterior** | **cavity** |
| **constitution** | **conductors** | **apartment** |
| **cone** | **principle** | **originally** |
| **consumed** | **explosive** | **suspend** |

## EQUILIBRIUM OF FLUIDS.

### Glossary of Scientific Terms, &c.

**e-qui-lib′-ri-um** ..........*equal balancing, or equality of force or weight.* [Lat. ÆQUUS, equal; LIBRA, a balance.]

**par′-ti-cles**......*atoms, or very small parts of which a body or fluid is composed.* [Lat. PARTICULA, a very small part.]

**grav′-i-ta-ting**......*moving by the action of gravity or the attraction of the earth.* [Lat. GRAVITAS, weight.]

**pen′-e-trate**...*to pass into, or to make a way within.* [Lat. PENETRO, I enter.]

**su-pe′-ri-or**...*greater, higher.* [Lat. SUPERIOR, higher, from SUPER, above.]

**in′-cline**......*bend, slope, lean towards.* [Lat. IN, towards; Gr. KLINO, I bend.]

**co-he′-sion**...*the act of sticking or clinging together.* [Lat. CON, together; HÆREO, I stick or cling.]

**re-sis′-tance**......*opposition to pressure.* [Lat. RE, against; SISTO, I stand.]

**lat′-er-al-ly**...*in a direction proceeding sideways or against the side.* [Lat. LATUS, a side.]

**a′-gi-tate**...*to set in motion, to stir violently.* [Lat. AGITO, I put in motion.]

**or′-i-fice**...*an opening of any kind.* [Lat. OS, ORIS, a mouth; FACIO, I make.]

**ve-loc′-i-ty**..*swiftness, rapidity.* [Lat. VELOX, swift.]

**op-po-si′-tion**.......*resistance to application of force of any kind.* [Lat. OB, against, or in the way; PONO, I place.]

The equilibrium of fluids is the natural result of their particles gravitating independently of each other; for when any particle of a fluid accidentally finds itself elevated above the rest, it is attracted down to the level of the surface of the fluid, and the readiness with which fluids yield to the slightest pressure will enable the particle by its weight to penetrate the surface of the fluid and mix with it. But this is the case only with fluids of equal density; for a light fluid will float on the surface of a heavy one, as oil on water, and air will rise to the surface of any liquid whatever, being forced up by the superior gravity of the liquid.

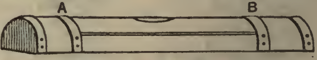


Fig. 1.—Spirit Level.

Fig. 1 represents an instrument called a spirit level, which is constructed upon the principle of the equilibrium of

fluids. It consists of a short tube, A B, closed at both ends, and containing spirit or water and a bubble of air. When the tube is not perfectly horizontal, the water runs to the lower end, which makes the bubble of air rise to the upper end, and it remains in the centre only when the tube does not incline on either side. It is by this means that the level of any situation to which we apply the instrument is ascertained.

Solid bodies, therefore, gravitate in masses, the strong cohesion of their particles making them weigh altogether; while every particle of a fluid may be considered as a separate mass, gravitating independently. Hence the resistance of a fluid is considerably less than that of a solid body. The particles of fluids, acting thus independently, press against each other in every direction, not only downwards but upwards, and laterally or sideways; and, in consequence of this equality of pressure, every particle remains at rest in the fluid. If you agitate the fluid, you disturb this equality; and the fluid will not rest till its equilibrium be restored.

Were there no lateral pressure, water would not flow from an opening on the side of a vessel; sand will not run out of such an opening, because there is scarcely any lateral pressure among the particles. Were the particles of fluids arranged in regular columns, as in Fig. 2, there would be no lateral pressure; for when one particle is perpendicularly above the other, it can only press it downwards; but as it must continually happen that a particle passes between two particles beneath, as in Fig. 3, these last suffer a lateral pressure, just as a wedge, driven into a piece of wood, separates the parts laterally. The lateral pressure is the result, therefore, of the pressure downwards, or the weight of the liquid above; and, con-

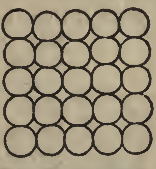

**Fig. 2.—Perpendicular Pressure.**

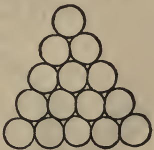

**Fig. 3.—Lateral Pressure.**

sequently, the lower the orifice is made in the vessel, the greater will be the velocity of the water rushing out of it. Fig. 4 represents the different degrees of velocity with which a liquid flows from a vessel furnished with three stop-cocks, at different heights. Since the lateral pressure is entirely owing to the pressure downwards, it is not affected by the horizontal dimensions of the vessel which contains the liquid, but merely by its depth; for as every particle acts independently of the rest, it is only the column of particles immediately above the orifice that can weigh upon and press out the liquid.

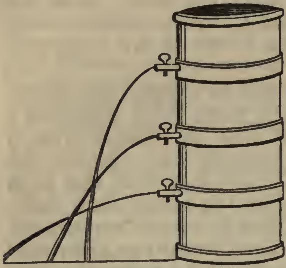

Fig. 4.

The pressure of liquids upwards, though it seems in direct opposition to gravity, is also a consequence of their pressure downwards. When, for example, water is poured into a tea-pot, the water rises in the spout to a level with that in the pot. The particles of water at the bottom of the pot are pressed upon by the particles above them; to this pressure they will yield, if there is any mode of making way for the superior particles, and as they cannot descend, they will change their direction and rise in the spout. Suppose the tea-pot to be filled with columns of particles of water, similar to those described in Fig. 5, the particle 1 at the bottom will be pressed laterally by the particle 2, and by this pressure be forced into the spout, where, meeting with the particle 3, it presses it upwards, and this pressure will be continued from 3 to 4, from 4 to 5, and so on, till the water in the spout has risen to a level with that in the pot.

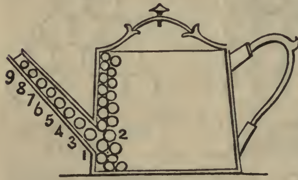


Fig. 5.

## Notes.

1. COHESION, a peculiar kind of force or attraction by which similar particles, or atoms of which individual bodies are composed, are held together. In bodies which are separated readily, such as water, or butter, the attraction of cohesion is slight, but in bodies which cannot be separated easily, as wood or iron, the attraction of cohesion is great. As wood can be separated more easily than iron, the cohesion of particles in this material is less strong than in iron. When a solid body is cut asunder or broken, the force of cohesion that previously held the parts together is destroyed, and cannot be restored.

2. EQUILIBRIUM.—A fluid is said to be in equilibrium when its particles are subjected to equal pressures in all directions. This is only the case when its surface is horizontal.

3. PARTICLES.—Particles of matter are the smallest atoms into which matter is supposed to be capable of division. Although, at first, it seems unreasonable to imagine that there is a point at which atoms of matter, how minute soever, are no longer capable of division, yet the greatest philosophers have thought otherwise. That great Christian, Sir Isaac Newton, says: "It seems probable to me that God, in the beginning, formed matter in solid, massy, hard, impenetrable, moveable particles, and in such proportion to space as most conduced to the end for which He formed them; and that these primitive particles, being solids, are incomparably harder than any porous bodies compounded of them; even so very hard as never to wear or break in pieces; no ordinary power being able to divide what God himself made one in the first creation."

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## THE SEA ANEMONE.

### GLOSSARY OF SCIENTIFIC TERMS, &c.

**pol′-y-pi**...*animals having one end formed like a sucker, by which they are able to secure themselves to rocks, &c., and numerous arms or feelers at the other end with which they capture their prey.* [Gr. POLUS, many; POUS, a foot.]

**ten-tac′-u-la**......*the arms or organs of feeling and capturing prey with which polypi are furnished.* [Lat. TENTACULUM, a feeler.]

**hy′-dra**.........*a kind of fresh-water polypus remarkable for its power of being multiplied*

*into numerous animals by division.* [Gr. HUDOR, water.]

**zo′-o-phytes**......*animals resembling vegetables in some points, and once supposed to partake of the nature of both, whence the name.* [Gr. ZŌ-ON, a living animal; PHYTON, a plant.]

**tu′-bi-pores**......*zoophytes contained in long cylindrical cells formed generally of calcareous or lime-like matter: they are often called organ-pipe coral.* [Lat. TUBUS, a pipe. Gr. POROS, a passage.]

**ac-tin′-e-æ**......*polypi belonging to the order retinea*; so called from the ray-like form and disposition of their feelers or tentacula. [Gr. AKTIN, a ray.]

**mad′-re-pores**......*hard substances resembling coral, beautifully variegated in appearance when cut and polished.* [Fr. MADRÉ, spotted.]

**cor′-al-lines**......*slender plant-like bodies with branches, consisting of small zoophytes in slight calcareous tubes.* [Lat. CORALLIUM, coral.]

At each ebb of the sea, short as the distance may be to which it withdraws its waters, insignificant as may be the strip of ocean's domain temporarily laid bare, yet it affords some glimpse of the strange and rare things which are profusely scattered on its bed. At each ebb we may gratify our rational curiosity by the contemplation of multitudes of organic beings, whose habits and modes of existence, differing materially from those of all terrestrial animals, display the multiform resources of Him who has fixed their boundary, appointed their habitation, and determined the laws of their existence. To the physiologist, some of the creatures which here present themselves are especially interesting; inasmuch as he may study in their structure the simplest modes of animal organisation, an organisation divested of all the complicated machinery which we observe when we look at any of the creatures of a higher grade; an organisation which, while it exhibits to our notice the laws of vitality in all their essential energy, is destitute of that assemblage of parts, which characterises the birds of the air, the beasts of the field, fishes, reptiles, and insects.

The animals thus interesting, from their low grade in the scale of organisation, and to which we at present allude, constitute that part of the zoophytes termed Polypi, so named from the numerous *tentacula* or filamentous feelers which encircle their mouth. The general form of polypi

is either cylindrical or conical; and in many no true stomach or intestines are discoverable, a simple cavity constituting the digestive apparatus. Some are of a fleshy texture, and, almost plant-like, remain fixed by their base to the surface of the rock; others are like masses of floating jelly, and when their substance is examined, it appears almost transparent, and of uniform consistence, filled with minute opaque points. Yet by means of the filaments which border their external margin they swim, they creep, they seize their prey, and transfer it into the mere cavity which serves as a stomach. They are very sensible of light, but what is more wonderful, they not only possess an unlimited power of reproducing such parts as are cut or torn away, but each part becomes a distinct animal, so that they may be thus artificially multiplied to any extent. Their natural mode of reproduction is by buds, or offsets, which spring out of different parts of the body, drop off, and grow; such form the genus *hydra.* Another group of polypi are either invested by, or invest, like jelly, a hard calcareous secretion; such are the tubipores, corallines, madrepores, &c., whose labours are so interesting, and yet so little understood. Another group, again, contains the sponges and their allies, whose gelatinous structure is diffused over an elastic fibrous *openwork*, and if exposed, soon dries away, leaving scarcely any trace behind.

It is, however, to the polypi, possessing a fleshy texture, and a somewhat higher degree of organisation, that we here wish to direct attention. The animals of this group are fixed at their base to the surface of rocks, but not permanently; most, at least, are able to creep on their basal portion, and many can detach themselves and swim, or float in the water, carried along by its current. The mouth which receives the food, and also rejects the indigestible portions, is capable of being opened or firmly contracted at will, and is encircled by tentacula, which are also retractile. The mouth opens into a stomach, of a simple sac-like form, and between this sac and the external skin there exists an organisation, the use of which is as yet obscure: it consists of vertical fibrous leaflets, to which adhere the ovaria, like intertwined fibres or threads. The

intervals, or spaces, between these leaflets communicate with the interior of the *tentacula;* and it appears that water is capable of entering into these spaces, whence it is discharged by little orifices round the mouth.

The examples of this group of polypi abound on all our coasts, where low reefs or crags afford them shelter. Who that has visited such parts of our shores has not seen the sea-anemone adhering by thousands to the sides, and under the projection of the rocks left bare by the retiring tide? Expanding their circle of tentacula, they seem like opening flowers, adorning the rock with purple blossoms; contracted, they resemble buds, glittering with dew.

The sea-anemones form the genus *actineæ;* they are remarkable for their rich colours, and the numerous tentacula which surround the mouth in several ranks, like the petals of a double flower. They are extremely sensible to the light, and expand or close according to the genial temperature and clearness of the day. On withdrawing the tentacula, the opening, whence these organs emerge, contracts and closes them in, like the mouth of a purse. The tentacula are the agents of procuring food; stretched out, they are feeling for their prey—small crabs, shells, little fish—which is no sooner felt than it is seized, entangled, and conveyed into the stomach, where it is rapidly digested.

For their powers of reproducing lost parts, and in the power of these parts to become distinct animals, they scarcely yield to the gelatinous polypi, the hydras. Their young are produced alive, the germ of each being conducted from the ovaries into the stomach.

The species most abundant on our shores is the purple actinea, or sea-anemone, *actinea equina,* a larger species, and the *actinea senilis*, which dwells principally in the sand, beneath which it is said to withdraw itself for safety.

These beautiful animals may be found on any rocky shore throughout the United Kingdom: when detached from the rocks to which they cling, which must be done with great care, and placed in a basin of salt water, the bottom of which has been strewn with flat stones and pebbles, they will unfold their tentacula when the sun shines on them.

## Exercise in Meanings and Derivation.—VI.

*Divide and accentuate each word, and give its meaning and derivation.*

| | | |
|---|---|---|
| temporarily | filamentous | retractile |
| profusely | cylindrical | vertical |
| rational | conical | fibrous |
| curiosity | intestines | expanding |
| terrestrial | external | contracted |
| multiform | margin | genial |
| physiologist | calcareous | emerge |
| divested | gelatinous | entangled |
| essential | basal | ovaries |

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# GEOLOGY, AND WHAT IT TEACHES.

## Glossary of Scientific Terms, &c.

**a'-que-ous**....*watery, or pertaining to water.* [Lat. AQUA, water.]

**ig'-ne-ous** ..*fiery, or pertaining to fire.* [Lat. IGNIS, fire.]

**plu-ton'-ic**......*formed by the action of fire.* [Lat. PLUTO, the heathen god of the regions of fire below the earth.]

**crys'-tal-line**......*having particles in the form of crystals, that is, of a definite geometrical form, with plane faces.* [Gr. KRYSTALLOS, ice, from the clearness and transparency of crystals ordinarily so called.]

**met-a-mor'-phic**...*subject to change; or, having changed, in the case of rocks, since deposition.* [Gr. META, implying change; MORPHE, form.]

**sed-i-ment'-a-ry**...*formed by the settlement of matter.* [Lat. SEDEO, I sit or settle.]

**pa-la'-o-zo-ic**......*belonging to ancient life.* [Gr. PALAIOS, old; ZOÖN, an animal.]

**vol-can'-ic**.........*produced by the agency of fire.* [Lat. VULCANUS, the heathen god of fire.]

**fos'-sils**...*petrified remains of animal and plant-life, so called because they are obtained by digging.* [Lat. FODIO, I dig; participle FOSSUS, dug.]

**fos-sil-i'-fe-rous**....*producing fossils.* [Lat. FOSSUS, dug; FERO, I bear or produce.]

**ne'-o-zo-ic**...*belonging to new or recent life.* [Gr. NEOS, new; ZOÖN, an animal.]

**ter'-ti-a-ry**...*third in order, so called because geological formations were once divided into primary, secondary, and tertiary.* [Lat. TERTIUS, the third.]

**o-o-lit-ic**.........*egg-like, from oolite, a kind of limestone, so called because its formation resembles the eggs in the roe of a fish.* [Gr. OÖN, an egg; LITHOS, a stone.]

**tri-as'-sic**...*belonging to the trias; a geological formation of sandstone, so called because it contains three distinct kinds of sandstone.* [Lat. TRES, TRIA, three.]

**si-lu'-ri-an**.. ......*a geological formation, especially noticeable in Wales, in the part formerly inhabited by the Silures, an ancient British tribe.*

**de-vo'-ni-an**......*a geological formation, so called because it is especially noticeable in Devonshire.*

**cre-ta'-ce-ous**......*chalky, or composed of chalk.* [Lat. CRETA, chalk.]

**perm'-i-an**.........*a geological formation, so called because it was first noticed near the city of Perm, in Russia in Europe.*

**car-bo-nif'-er-ous**...*coal producing.* [Lat. CARBO, coal; FERO, I bear or produce.]

**hy'-po-zo-ic**....*below life, or, in rocks, below the strata, in which remains of life have been found.* [Gr. HUPO, below; ZOÖN, an animal.]

GEOLOGY is a Greek word, compounded of *ghe*, the earth, and *logos*, a discourse. While it is obvious that it constitutes a very important and attractive study, it is equally plain that it is attended with considerable difficulties; in consequence, especially, of our inability to penetrate far below the surface of our globe, and in fact the restriction of our examinations to only a portion of the land. We stand on the borders of oceans and rivers, or look into ravines, mines, and the clefts of mountains, like insects that skim the surface or pace the rim of a small vessel of water, or traverse the little mole-hill in the footpath. How insignificant is man, a worm of the earth! and yet how great and "accounted of," as intelligent, responsible, and immortal!

We might here advert to some of the systems which have been framed to explain the present appearances of the surface, or, as it has been called, the crust of the earth; but instead of giving statements of this nature, it will be better to restrict our remarks to some of the principal facts which have beeen observed. Great diversities of opinion have prevailed on many points among geologists; and, although our knowledge of facts is continually increasing, we cannot be said to have yet advanced beyond the surface of the science.

Naturally, one of the first subjects of remark is the

position, relative situation, and general character of the rocks that constitute the structure of the earth. They not only differ from each other in their essential elements, but in their figure, magnitude, and position, as well as in other circumstances. They lie in strata or beds, and layers. The Latin word *stratum*, of which strata is the plural, signifies bed, and is used to express the order of rocks. Hence, when a mountain, or series of rocks, is composed of a similar and undivided mass, it is said to be unstratified; which, however, is comparatively rare. The crust of the earth, regarded as a whole, is disposed in layers or beds of earth, stone, and various materials, and is, therefore, stratified. These strata are, in one respect, regular; in another, extremely irregular. In the order in which they occur, nothing can be more regular; but in the direction or inclination in which they are found, the utmost irregularity prevails.

Before giving a delineation of the order of stratified rocks, we must remark that, although this exhibits the law or rule as to the succession of strata, they following each other invariably after this manner, yet all are not found in every, or indeed together in any entire series, in any one situation. Many of the particular classes are always absent; and there may be only two or three present. But the law of succession is never violated; that is, those which sustain others are never uppermost and recumbent upon them, and *vice versa*. If one, two, or more of a series is missing, the rest in going downwards are all rocks of the classes below the one in question; or upwards, those which belong to a superincumbent series. In this respect, therefore, there is no confusion.

The position of the strata, however, is extremely irregular. Some are horizontal; some almost or quite perpendicular; and the dip or inclination of others is diversified at every possible angle. To a superficial observer, this disarrangement appears accidental, and he is naturally disposed to regard the directions, inclinations, and frequent convolutions of the masses as mere confusion, as if all had been thrown together by some mighty power into a disorderly mass. This very disorder, however, is an unquestionable proof of design and wise superintendence—

a design which pervades the universe as well in its apparent contingencies, as in its most consecutive arrangements and nicest adaptations. If all the strata or layers of rocks on the earth's surface had been placed horizontally one above the other, it is evident that we could only have become acquainted with the superior series; and beds of coal, salt, metals, and other substances which belong to the inferior strata could never have been available. Upon the supposition, too, that these layers had been wrapped round the nucleus or solid body of the globe like the coats of an onion, the earth would have presented nothing to the eye but a monotonous plain; innumerable varieties of animal and vegetable life could not have existed; and the fertility which now results from the descent of dew, the formation of springs, the gathered waters of lakes and inner seas, and the flow of rivers, would have been precluded. What modifications of beauty, then, what combinations of utility everywhere challenge our admiration and love of His wisdom, power, and benignity who governs the universe!

The rocks composing what we term the crust of the earth are divided into two great classes; firstly, those that are due to the agency of water; and, secondly, those that are due to the agency of fire. The former are called Aqueous Formations, the latter Igneous Formations.

Of the Igneous Formations, or formations due to the action of fire, there are two kinds, the Plutonic, such as granite, and the Volcanic, such as basalt. These rocks are crystalline and unstratified, that is, they occur in masses, and not in layers, as rocks produced by the action of water.

Of the Aqueous Formations, or formations due to the action of water, there are also two kinds, the Metamorphic, or Unfossiliferous, which contain no fossils or remains of animal life; and the Sedementary or Fossiliferous, which yield fossils of various kinds.

The sedimentary rocks, or strata, have been subdivided into two great series, according to the fossils or forms of life which they exhibit when compared with forms of life of the present day. These subdivisions are styled respectively the Palæozoic and the Neozoic, the former containing fossils of the ancient type of life, the latter those of the

modern form of life. These names are also applied to the periods in which the formations in each subdivision are concluded to have taken place. Thus the later sedementary formations were deposited in the Neozoic Period, and the earlier sedimentary formations in the Palœozoic Period. The metamorphic strata are said to belong to the Hypozoic Period, or the period below that in which signs of animal and plant life have been detected, because up to the present time no fossils have been found in rocks belonging to this period, though it cannot be asserted positively that none exist in them.

We may now proceed to a tabular view of the successive formations belonging to the Neozoic and Palæozoic periods, and name some of the rocks belonging to each formation, and the fossils that are found in them.

I.—Neozoic Period.

| Formations. | Rocks, etc. | Fossils. |
|---|---|---|
| 1. **Post. Tertiary** ...... | Peat; Deltas of Rivers; Ancient Beach of Brighton; Bluffs of the Mississippi; Brixham Cave; Australian Breccias. | Human Remains; Mastodon. |
| 2. **Tertiary** .. | Mammalian Beds; Norwich Crag; Red and Coralline Crag (Suffolk, Antwerp); Virginia Sands and Touraine Beds; Volcanic Tuff and Limestone of the Azores; Brown Coal of Germany, Fresh-water and Marine Beds; Barton Clays; Bracklesham Sands; Paris Gypsum; London Plastic and Thanet Clays. | Marine Shells; Mastodon; Gigantic Elk; Salamander; Palms, Birds, &c. |
| 3. **Cretaceous** | British Chalk; Chalk with and without flints: Chalk Marl; Upper Green Sand; Gault; Lower Green Sand; Kentish Rag; Weald Clay; Hastings Sand. | Mesosaurus; Fish; Molluscs; Iguanodon; Hylæosaurus. |
| 4. **Oolitic** .... | Purbeck Beds; Portland Stone and Sand; Kimmeridge Clay; Calcareous Grit, Coral Rag; Oxford Clay; Cornbrush; Forest Marble; Bradford Clay; Great Oolite; Stonesfield Slate; Fuller's Earth; Inferior Oolite. | Fish; Belemnites; Ammonites; Icthyosaurus; Plesiosaurus; Pterodactyl. |
| 5. **Triassic**.... | Lias Clay and Marl Stone; White Lias; Red Clay; Cheshire Salt; Virginia Coal Fields; Muschekalk; New Red Sandstone (Lancashire and Cheshire.) | Ammonites; Equisetum; Amphibia; Encrinus; Labyrinthodon; Footprints of Birds and Reptiles. |

II.—Palæozoic Period.

| Formations. | Rocks, etc. | Fossils. |
|---|---|---|
| 1. **Permian** .. | Magnesian Limestone; Marl Slates; Red Sandstone and Shale; Dolomite. | Firs; Fishes; Amphibia. |
| 2. **Carboniferous** ...... | Coal Measures; Millstone Grit; Mountain Limestone. | Ferns; Calamites |
| 3. **Devonian** .. | Tilestones: Cornstones and Marls; Quartzose Conglomerates. | Shells; Fish; Trilobites. |
| 4. **Silurian** .. | Ludlow Shales; Wenlock Limestone and Shales; Caradoc Sandstone; Llandeilo Flags, Bala Limestone; Bangor Slates and Grits; Huronian Series of Canada; Gneiss; Quartzites; Interstratified Limestone | Sponges; Corals; Shells; Zoophytes; Ferns; Sigillaria; Calamites; Cryptogamia; Eozoön Canadense. |

The above comprises the order in which the various kinds of stratified rocks are considered by geologists to have been deposited. In future reading lessons the attention of the reader will be directed to the wonders of the coal formation and the various marbles and stones used in building.

## COMETS.

No branch of astronomy is so imperfect as that which relates to comets. The reason is obvious. These illustrious strangers, although they attract more curiosity and attention than the regular luminaries of heaven, are yet generally so unexpected in their appearance, remain so short a time visible to us, are so unequal in their movements, and so eccentric in their courses, that it is difficult accurately to determine their orbits, their periods, or their nature.

The name of comets is derived from the hairy appearance which some of them exhibit when in certain positions with regard to the sun; as the Latin word for a comet, *comēta* is formed from *coma*, hair. That they ought to be ranked among the heavenly bodies was allowed by the most eminent of the ancient philosophers, particularly by the Pythagoreans and the whole Italian sect. The Peripatetics, however, maintained that they were nothing more than a peculiar kind of meteors within our atmosphere. The former opinion is now generally admitted, and is evidently

the most correct; because, when seen from different places, they appear at the same distance from fixed stars which are near them, which could not be unless their parallax was very small, and consequently their distance very great.

It appears that comets describe curve-lines about the sun, and that their orbits, like those of planets, are probably elliptical, or nearly so. But for the ease of computation, they are considered as parabolas, or rather those parts of them which are visible to us, and which do not differ so much from ellipses, especially in that small portion of them, as to occasion any sensible error by the change. In making these computations, it will be necessary, as in the case of the planets, to distribute the inequalities of their motions among the different parts of their orbits, and thus to obtain a result as correct as possible upon the whole. Still, in such very eccentric orbits as those in which comets move, and the irregularity of their appearance, it is very difficult to obtain the necessary data with desirable accuracy, and hence the utmost caution is necessary in every part of the process, and even then too much dependence must not be placed upon the results.

There are on record accounts of more than 500 comets which have been observed since the commencement of the Christian era, and more than a hundred before that time. Of 98 comets whose elements have been observed and calculated previously to the year 1808, 24 have passed between the sun and the orbit of Mercury, 33 between the orbits of Venus and the earth, 16 between the orbits of the earth and Mars, three between the orbits of Mars and Ceres, and one between those of Ceres and Jupiter. Their orbits are inclined to the ecliptic in every variety of angle, and their courses also differ in direction, nearly one-half of them moving from west to east, and the other half the contrary way. A few appear to be confined within the limits of our system, while the greater number range far beyond it.

It is owing to the difficulties above-mentioned that, among so large a number of comets as have been observed, there are only three, or at the most four, whose returns have been satisfactorily ascertained: these are Dr. Halley's, Encke's, Biela's, and a fourth, whose orbit is passed through

in twenty years. The first appeared in 1682, and re-appeared in 1759, after a period of more than seventy-six years; it was expected again in 1835. Its orbit extends about twice as far as Uranus. The period of Encke's comet is three years and a quarter, and its orbit is included within that of Jupiter. Biela's, also visible in 1832, extends not so far as Saturn, and performs its revolution in six years and three quarters. The length of the period is sometimes affected by the action of the planet Jupiter, if the comets pass near it.

Very remarkable comets appeared in the years 1807, 1808, 1811, 1819, and 1825; but among them all, the most splendid was that of 1811, which appeared in all its brilliance during several months of the summer and autumn of that year, and was accompanied by a magnificent train of light, or tail, as it is usually termed, subtending several degrees to the eye, and probably was some millions of miles in length. In the course of the year 1825 five comets were visible.

But what are comets? Many have been observed, and the orbits and motions of some have been calculated. But what is their nature, their substance, or the purpose they were intended to answer in the general system?—are questions not yet decided, nor very likely to be. So varied are their aspects, and so distinct are they from all other bodies, to which in some respects they yet bear an analogy, that we need not wonder at the scantiness of our knowledge in relation to them. Sir Isaac Newton considered them to be compact, solid, fixed, and durable bodies, capable of bearing exceedingly great degrees of heat and cold without dissolution; in fact, a kind of planets which move in very oblique and eccentric orbits, every way with the greatest freedom, persevering in their motions even against the course and direction of the planets. Their tail he supposed to be a very thin and slender vapour, emitted by the head or nucleus of the comet, ignited or heated by the sun. With this hypothesis the phenomena of some of the larger comets appear very well to agree; but several noted astronomers—Dr. Halley among the number—have advanced several objections against it, and maintain that the

tail of a comet is formed of matter which has not the power of refracting and reflecting light, but that it is a lucid or self-shining substance. With respect to the body of a comet, Dr. Herschel has affirmed that, after a diligent examination of several by the most powerful of his telescopes, he could not perceive the least appearance of any solid nucleus, as they seemed to be mere collections of vapours condensed about the centre of each. As to the uses of these singular bodies—these temporary planets, if they be such—some have supposed that they were intended to supply the waste of the sun occasioned by the constant emission of his beams ; and the ignorant, in former ages, have beheld them with superstitious veneration, as tokens of the Divine displeasure, as omens of evil, and precursors of the most dreadful calamities ; and as malignant demons,

> That from their horrid hair
> Shook pestilence and wars.

Among more recent comets may be named Donati's, so called from its having been discovered by Donati, an Italian astronomer, at Florence, in 1858, when it was calculated to be 228,000,000 miles from the earth. This comet, whose tail was 40,000,000 miles long, was considered by many to have presented as brilliant an appearance as the great comet of 1811. A fine comet was discovered by Mr. Tebbutt, at Sydney, in Australia, in 1861, with a nucleus of 400 miles in breadth. It was calculated that this comet travelled at the rate of upwards of 415,000 miles an hour, and the earth was supposed to have passed through its tail.

But the most singular supposition was that uttered in the beginning of the last century by the celebrated William Whiston. He imagined them to be the prison-houses of those who are condemned to future punishment, and that thus "wheeled from the remotest limits of the system, the chilling regions of darkness and cold, the comet wafted them into the very vicinity of the sun, and thus alternately hurried its wretched tenants to the terrifying extremes of perishing cold and devouring fire."

But, speculation apart, there is one truth which philosophy, reason, and revelation concur to establish—that He

who made these and all the other wonders of creation, holds them under his immediate and absolute control, appoints their courses, regulates their motions, and makes them subservient to his own glory and his people's good, in a manner which, though we "know not now, we shall know hereafter." Meanwhile, humility and adoration become us, delight in his service, and confidence in his love.

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## Exercise in Meanings and Derivation.—VII.

*Divide and accentuate each word and give its meaning and derivation.*

| | | |
|---|---|---|
| **astronomy** | **ecliptic** | **malignant** |
| **orbits** | **scantiness** | **subservient** |
| **parallax** | **nucleus** | **eccentric** |
| **data** | **calamities** | **meteors** |
| **analogy** | **control** | **ellipses** |
| **hypothesis** | **luminaries** | **decided** |
| **precursors** | **philosophers** | **persevering** |
| **revelation** | **parabolas** | **veneration** |
| **obvious** | **revolution** | **speculation** |
| **comet** | **dissolution** | **adoration** |
| **elliptical** | **emission** | **confidence** |

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## Notes.

PYTHAGOREANS.—The followers of Pythagoras, of Samos, head of the Italic sect who flourished about 555, B. C. He taught the doctrine of transmigration, or the transmission of the human soul from one body to another. He considered that the universe was created from a shapeless mass by an all-powerful being, who was the soul and mover of the world; and taught that the earth and planets revolve round the sun.

PERIPATETICS.—The followers of the Grecian philosopher, Aristotle, who was accustomed to deliver his lectures to his disciples as they walked about. The word is derived from the Greek PERI, about; and PATEO, I walk.

PARALLAX.—The change in position of a heavenly body, in consequence of being viewed from different points; the greater the distance of the body the smaller the parallax. From the Greek PARA, beyond; and ALLASSO, I wander.

ASTRONOMERS.—Biela, Encke, Halley, Herschel, and Newton

were celebrated astronomers and mathematicians. BIELA Wilhelm von (German), born 1782; discovered the comet which bears his name, 1826; died 1856. ENCKE Johann Franz (German), born 1791; shewed that Pons's comet was identical with those of Herschel and Mechain, 1831; died 1865. HALLEY Edmund, D.D., born 1656; made astronomer royal 1720; died 1742. HERSCHEL Sir Frederick William (German), born 1738; came to London and settled as an organist 1757; discovered the planet Uranus, 1781; died 1822. NEWTON Sir Isaac, born 1642; discovered the composition of white light 1666; published his theory of gravitation 1687; died 1727.

WHISTON William, D.D., an eminent but highly eccentric mathematician and theologian, born 1667; became Lucasian professor of mathematics at Cambridge in 1703, when he succeeded Sir Isaac Newton; but was expelled from his professorship seven years after for having broached heretical opinions on certain points of faith. He translated and published the works of Josephus, the Jewish historian, 1737, and died in 1752.

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# INSECTS: THEIR STRUCTURE AND HABITS.

## PART I.—JAWS: ANTENNÆ AND EYES.

### GLOSSARY OF SCIENTIFIC TERMS, &c.

**in′-sect**...*any animal, such as a wasp or fly, with a body as if cut into in the middle, or divided into sections.* [Lat. INSECTUM, an insect, from IN, into; SECO, I cut.]

**ab-do′-men**...*the lower part of the belly; in insects the portion united by the thread-like ligament to the thorax.* [Lat. ABDOMEN, the belly.]

**gal′-le-ries**......*long passages, generally lighted on one side, and giving access to apartments of a private character.* [Fr. GALERIÈ.]

**e-jec′-tion**...*act of casting out.* [Lat. E, from; JACIO, I throw.]

**com′-pli-ca-ted**......*involved, intricate, having many parts.* [Lat. CON, together; PLICO, I fold.]

**man′-di-bles**.... .*organs made for the purpose of chewing; in insects the upper jaws.* [Lat. MANDO, I chew.]

**in-stinct′-ive**...*prompted by the natural impulse which supplies the place of reason in animals.* [Lat. INSTINGUO, I instigate.]

**mas′-ti-cate**.. *to chew or grind into pulp with the teeth.* [Lat. MASTICO, I chew.]

**par′-al-lel**...*beside one another, side by side.* [Gr. PARA, by; ALLELOS, one another.]

**col-on-nades′**........*ranges of columns.* [It. COLONNA, a column, from Lat. COLUMNA.

**con-glom′-er-ate**.....*gathered together into a mass like a ball.* [Lat. CON, together; GLOMUS, a ball.]

**in-tel-lec′-tu-al**...*relating to the power of understanding.* [Lat. INTELLIGO, I choose between; from INTER, between; LEGO, I choose or select.]

**an-ten-næ**... ..*the horns or feelers of insects.* [Lat. ANTENNA, the yard or beam of a sail.]

**tac′-tors**...*touchers or feelers.* [Lat. TANGO, I touch; participle TACTUS, touched.]

**col-e-op′-te-rous** ...... *having sheaths for the wings, like beetles.* [Gr. KOLEOS, a sheath; PTERON, a wing.]

**ar-cades′**......*passages arched over or covered with a vaulted roof.* [Lat. ARCUS, a bow.]

**mil′-le-pede** ..*an animal with a great number of feet ranged on each side.* [Lat. MILLE, a thousand; PES, a foot.]

**hex-ag′-o-nal**......*having six sides and six angles.* [Gr. HEX, six; GŌNIA, an angle.]

**pel′-lu-cid**......*perfectly clear, transparent.* [Lat. PER, through; LUCIDUS, bright.]

**stem′-ma-ta**...eyes or visual organs in certain insects. [Gr. STEMMA, a garland.]

The term insect is often applied not only to the grasshopper, the fly, and the beetle, but to other small animals, such as slugs and worms. If, however, one of the former be examined, its body will appear insected, being divided, as it were, into three principal pieces; the head, the trunk, and the abdomen; and it is only where such a division is more or less obvious that this name can properly be given. A recollection that the English word is an adaptation of a Latin term, that signifies "cut between," will effectually guard against mistake.

While this part of animated nature is deeply interesting, it is eminently calculated to direct the mind to the great Creator of all. "If," says Basil, "you speak of a fly, a gnat, or a bee, your conversation will be a sort of demonstration of His power whose hand formed them; for the wisdom of the workman is commonly perceived in that which is of little size. He who has stretched out the heavens, and dug up the bottom of the sea, is also he who has pierced a

passage through the sting of a bee for the ejection of its poison." Or, to quote from our favourite Cowper :—

'Tis sweet to muse upon his skill displayed
(Infinite skill) in all that he has made!
To trace in Nature's most minute design,
The signature and stamp of pow'r divine;
Contrivance intricate, express'd with ease,
When unassisted sight no beauty sees;
The shapely limb and lubricated joint,
Within the small dimensions of a point:
Muscle and nerve miraculously spun,
His mighty work, who speaks, and it is done!

It is proposed, therefore, to furnish some observations on their more remarkable organs, which will tend to show that the gigantic bulk of other creatures does not include a more complicated machine than those little forms which, though often unnoticed, are no less wonderful. "I have," says Kirby, "an undescribed beetle, which possesses every organ usually found in the order it belongs to, which is absolutely not bigger than the full stop that closes the period." Equally perfect in its kind is every creature, however minute.

*The Jaws.*—The substance of these parts is hard, horny, and of considerable strength, and their structure is admirably adapted for their intended services: some armed with spines and branches for tearing flesh; others hooked for seizing, and at the same time hollow for suction; some calculated like shears for gnawing leaves; and others more resembling grindstones, able to reduce the hardest wood. The major part of eating insects have indeed an upper and under pair of jaws, both placed horizontally, the former in order to seize and masticate the prey; the latter, when hooked, for retaining and tearing, while the upper reduce it to powder before it is swallowed.

To some insects the mandibles, or upper jaws, supply the place of trowels, spades, and pickaxes; to others that of saws, scissors, and knives, and, indeed, divers instruments. The jet-ant, for instance, works always in the interior of trees, and on one side may be found horizontal galleries, which follow the circular direction of the layers of the wood, and on another parallel galleries, separated by extremely thin partitions, having no communication except

by a few oval openings. Within the galleries separate chambers are formed. Pillars too, appear, originally arched at both ends, and then worked into regular columns. Colonnades sustain the upper storeys, and leave a free communication throughout the whole extent. The celebrated Huber, who observed these things, says: "I have seen fragments of from eight to ten inches in length, and of equal height, formed of wood as thin as paper, containing a number of apartments, and presenting the most singular appearance. At the entrance of these apartments, worked out with so much care, are very considerable openings; but in place of chambers and extensive galleries, the layers of wood are hewn in arcades, allowing the ants a free passage in every direction. These may be regarded as the gates or vestibules, conducting to the several lodges."

With the same instruments, the rose-leaf cutter bee makes a nest of portions of leaves, which is sometimes eighteen inches long. The pieces for this she cuts off most accurately, forming what is like a set of thimbles put one upon another, and inclosed in a case; and then she prepares a round piece to close it, so that, being filled with honey and placed horizontally, not a drop can escape. "Truly," as Reaumur has remarked, "whether this is attained by instinctive or intellectual means, the glory is due to that Intelligence which makes them and us."

*The Antennæ or Horns.*—Of all the organs of insects none seem more important to them than these, and none are certainly more wonderful or various in their structure. No insect has more than two, which are inserted in the crust of the head, together with an appropriate series of muscles and nerves. As it is necessary they should be under the direction of the eyes, they are always situated in the space between them, or in that below them. They vary in length, being sometimes short, and in one case more than four times as long as the body. They consist in general of a number of tubular joints, each having a separate motion, which enables the animal to give them every flexure necessary for its purposes. They are either generally or partially covered with down or hairs; and in some aquatic beetles they have a part which, like the lid

of a box, shuts them in when unemployed, and protects them from the water.

The great majority are employed by insects as tactors, to explore their way. When some of them, and more particularly the coleopterous, or wing-sheathed, are about to move from any place of rest, they first, and before they take a step, expand their antennæ—which have either been carefully laid up in a cavity fitted to receive them, or back upon the body—probably to ascertain the state of the atmosphere. As the animal begins to move, they in many cases do the same, and continue their action till it stops and returns to a state of repose. In some tribes the vibration is almost constant; others, when one horn is raised, depress the other, as if, by those means, they balanced themselves.

Some naturalists have considered them organs of hearing. "A little moth," says Kirby, "was reposing upon my window; I made a quiet, not loud, but distinct noise; the antennæ nearest to me immediately moved towards me. I repeated the noise at least a dozen times, and it was followed every time by the same motion of that organ; till at length the insect, being alarmed, became more agitated and violent in its motions. In this instance it could not be touch; since the antennæ was not applied to a surface, but directed towards the quarter from which the sound came, as if to listen."

They seem too to be a medium of communication. When, for instance, the bees have lost their queen, the hive goes on well for about an hour; afterwards a few of the workers appear much agitated, forsake the young, relinquish their labour, and begin to pace about in a furious manner. Whenever they meet a companion, they cross their antennæ; and the one that seems first to have observed the national loss tells the sad news to its neighbour, by giving it a gentle tap with these organs. This one becomes agitated in its turn, and runs over the cells, crossing and striking others; and thus, in a short time, the whole hive is in confusion. It is thought by some that the antennæ are also organs of smell, and possibly many of their uses have yet to be discovered.

*The Eyes.*—These include, as it has been well said, "a world of wonders." Some eyes are called simple, and vary in number from two to sixteen. In many they are imbedded, as usual, in the head; but in a little scarlet mite they stand upon a small foot-stalk, that the hairiness of this animal may not impede its sight. Other eyes are called conglomerate, because they are collected into a body; thus in the common millepede there are twenty-eight, placed in seven rows, and forming a triangle, having seven at the bottom and one at the top. Others are called compound, and when under a microscope seem to consist of an infinite number of hexagonal, or six-sided pieces. The eyes of many horse-flies have vivid bands of purple and green; others are spotted, and one has the figure of a flower painted in red on a black ground. These colours and markings are all most vivid and brilliant in the living insect, and often give that animation and fire to the eyes for which those of the higher animals are remarkable.

Insects have also pellucid spots, called stemmata, frequently arranged in a triangle, and which are organs of vision as well as the compound eyes. This was proved by an experiment with the common hive bee, from which also it appears that the compound eyes are for horizontal, and the stemmata for vertical sight. The eye of this insect is very curious. The outer coat is stiff, hard, flexible, and transparent, similar to a very thin plate of horn. It is not smooth as in men and other animals, but has various and manifold divisions, somewhat resembling little globes, and hence it was supposed to be an innumerable multitude of little eyes. The divisions, however, are rather six-sided, exactly like the closed cells of the comb or a little net. The eye is also very thickly covered with hair, serving, it is thought, instead of eye-brows or eye-lashes; the hairs, resembling bristles, being round, and tapering from the root to a fine point. Their number is very great; they appear so closely set as to form a thick forest of bristles, and are probably intended to keep it from injury.

The eyes of insects are *not movable* like those of larger animals; but they are so constructed that, while others have but two points of sight, they have myriads!

## Notes.

1. Cowper, William, the poet, was born 1731; died 1800. In becoming the poet of Christianity, Cowper addressed himself especially to the common business of life. He preached to us in our amusements and occupations. He was uniformly sober, harmonious, and reflective. His letters, which have been collected and published, we recommend as the perfect pattern of domestic correspondence; pure in language as in thought, they express the most familiar subjects in elegant simplicity.

2. Huber, François, a naturalist, born at Geneva in 1750; died at Lausanne, 1831. Although he was totally blind in consequence of a severe cold caught on a winter night in the snow, he made many interesting discoveries with regard to the habits of bees and their social organisation, which he published in a clever work on this subject.

3. Kirby, William, a clergyman, who, by his habits of research in his favourite pursuit, that of entomology, became one of the first entomologists of his time. He was born in 1759, and died in 1850. He wrote, among other works, an "Introduction to Entomology," in conjunction with Mr. Spence, and one of the series known as the Bridgewater Treatises, entitled, "On the History, Habits, and Instincts of Animals."

4. Reaumur, René Antoine Ferchault de, a naturalist and natural philosopher, born in 1683, at Rochelle, and died in 1757. He invented the thermometer which bears his name, and wrote a valuable work detailing his observations on the habits of insects.

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### PART II.—ARMS, LEGS, AND FEET.—WINGS.—OVIPOSITORS.

*Arms, Legs, and Feet.*—Every creature "falls into the niche it was ordained to fill," and for which it is expressly adapted. Thus the mole-cricket burrows in the ground, and forms extensive galleries, similar to those of its namesake, though smaller; and hence it has, if they may so be called, arms and hands of great strength, moved by a peculiar apparatus of muscles. The former are broad, and the latter are furnished with five long sharp claws, pointing somewhat obliquely outwards, this being the direction in which it digs, strewing the earth on each side of its course. Its whole structure is also as well fitted to its work.

Bees use in their cells a brown, odorous, resinous substance, called propolis, collected from various trees, for cementing and varnishing. When about to be carried away, it is first kneaded till it is somewhat dry and adhesive, and then the bee transfers it to a little receptacle with which she has been wonderfully provided. The shin, or middle portion of the hind pair of legs, is actually formed into a triangular basket, the bottom of which is composed of a smooth, shining, horn-like substance, hollowed out in the substance of the limb, and surrounded with a border of strong and thickly-set bristles, securing what the basket contains, and even allowing the load to be heaped beyond their points, without letting it fall.

The common fly walks up windows and walls, and it may often be seen on ceilings. Some have thought that these creatures have sponges on their feet, filled with a sticky substance, which enables them to adhere to such surfaces ; and others, that this is done by the feet being beset with small bristles. Sir Everard Home found, however, that they have flat skins or flaps, like the feet of ducks and other web-footed animals, and towards the back part or heel, but inside the skin or flap, two very small toes, so connected with the flap as to draw it close down on the glass or wall where the fly walks, and to squeeze out the air between the foot and the glass or wall. The pressure of the external air, therefore, holds it fast for a time, as a boy's sucker of leather adheres to a stone ; and as he lets in the air that it may be detached, so does the fly when it wishes its foot to be disengaged.

*The Wings.*—Every wing consists of two membranes, more or less transparent, applied to each other : the upper one being very strongly attached to the nervures or veins, and the lower adhering more loosely, so as to be separable from them. The nervures are a kind of hollow tube, which originate in the trunk, and diminish gradually, the marginal ones excepted, to their termination, and appear to contain air-vessels. The expansion of the wing is supposed to arise from a subtile fluid being introduced into these vessels, and thus an impulse is given to every part of this remarkable organ, so that it is supported in its flight like a sail by its

cordage. It is aided also by other means which we have not space particularly to describe.

The wings of butterflies, sphinxes, and moths are covered with scales so very minute as to be taken for extremely fine dust, placed in the most perfect order, and having a great diversity of beautiful colours. They have been well compared to mosaic work, produced by small pieces of variously coloured glass, stuck in a kind of paste, yet so minute as hardly to be perceived; looking rather like a picture whose parts are harmoniously combined. But here art is infinitely surpassed. A piece of the wing of a peacock butterfly, a quarter of an inch square, was placed under a microscope, when seventy rows, each containing ninety scales, were counted; there were, therefore, six thousand three hundred scales on one side of this small portion of wing, and a square inch must have the amazing number of one hundred thousand seven hundred and thirty-six scales. The number of glass pins in a square inch of fine mosaic is only eight hundred and seventy, so that it is one hundred and fifteen times coarser than the wing of this butterfly, which is of middle size, and the scales of which are proportional. What, then, must be the comparison with some of the smaller tribes, whose whole dimensions are a quarter of an inch?

The wing of a peacock butterfly, prematurely taken out of a chrysalis, proved to be nine and a quarter times finer than that of the perfect insect; so that it was ten thousand and sixty-three times finer than the most boasted mosaic.

The most superb of all the butterflies is the Imperial Trojan. It is a native of Amboyna, of an exceedingly rich green colour, having a fine golden tinge diffused through it; and "it may be doubted," says Linnæus, "whether nature has produced any object more beautiful amongst insects." It measures upwards of seven inches and a half from the tip of one wing to that of the other.

Many insects can fly in all directions without turning.

*Ovipositors.*—Most insects have an instrument called an ovipositor, by which they lay their eggs in proper places, and where the grub may find food as soon as it is born. This is one of the most remarkable gifts which God has bestowed on these little creatures, both as to its structure and

its operation. Sometimes it has one part inside another, like the pieces of a telescope ; at others it is cylindrical, ending in a pair of joints, which seem to act as forceps or pincers, including a tube (probably to convey the egg, that the pincers may introduce it) ; and at others bent like a sabre.

The auger, as Reaumur calls it, of the cicada, which some improperly style the grasshopper, is composed of a horny substance, and lodged in a sheath, which lies in a groove of the last ring of the belly. A slight pressure brings it forth, when it appears to be of equal thickness throughout, except at the point, where it is somewhat enlarged and angular, and has fine teeth on both sides. The sheath is composed of two horny pieces slightly curved, and ending in the form of a long spoon, so that the concave or hollow part may receive the convex or rounded end of the ovipositor.

On examining this instrument with a microscope, there will appear nine strong teeth on each side, placed very regularly, and becoming finer towards the point, where there are three or four very small ones. Simple as it seems, it is composed of three pieces, two outer, armed with the teeth before mentioned, which Reaumur denominates files, and another pointed like a lancet, and not toothed. The former can be moved backwards and forwards, while the latter remains fixed, and the means by which the three pieces are held united, while the files can easily be put in motion, are most exquisitely contrived. Besides the muscles necessary for the movement of the files, the handle of each ends in a curve of the same hard substance as itself, which not only supplies the muscles with a sort of lever, but serves to press, as a spring, the two files close to the central piece.

A most singular ovipositor in the body of a little four-winged creature has obtained for it the name of the saw-fly. The grubs, which often strip rose, gooseberry, raspberry, and red-currant trees of their leaves, and invade the birch, alder, and willow, may be known by having from sixteen to twenty-eight feet, by which they usually hang to the leaf they feed on, while the hinder part of the body is coiled up like a watch-spring. Some of the most common of the perfect flies have a flat body, of a yellow or orange colour, while the head and shoulders are black.

These insects have, in a sheath, a saw of a horny substance, with which they penetrate the branches and other parts of plants, in order to deposit their eggs. In some respects it is like, and in others unlike, the cabinet maker's tenon-saw, which is made of a thin plate of steel fitted into an iron back. The insect's saw has a back; but while the former has a narrow groove cut to receive the plate which is fixed, the groove of the latter is in the plate, and receives a ridge from the back, which is not fixed, but allows the saw to slide backwards or forwards, as it is thrown out or drawn in. The tenon-saw is single, but that of the insect is double, being, in fact, two distinct saws; in using which one is thrown out and, as it returns, the other is pushed forward, and this motion proceeds till the incision is made, when the saws, receding from each other, conduct the egg between them into its place. In the tenon-saw the teeth are alternately bent towards the sides, that the cut may allow the blade to move easily; and to answer the purpose in some degree, the teeth of the insect's saw are a little twisted, and on the outer side of each small teeth are placed to act as a rasp. When by this extraordinary instrument a groove is made, and an egg placed in the cavity, about two-thirds of the saw is drawn into its sheath, and a liquid, something like soap-lather, is dropped over the egg, to glue it to the spot, or defend it from the juices of the tree. One fly was observed to make six grooves in succession, which occupied her about ten hours and a half.

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## Exercise in Meanings and Derivation.—VIII.

*Divide and accentuate each word, and give its meaning and derivation.*

| | | |
|---|---|---|
| **peculiar** | **harmoniously** | **beset** |
| **odorous** | **surpassed** | **detached** |
| **propolis** | **proportional** | **nervures** |
| **varnishing** | **chrysalis** | **subtile** |
| **adhesive** | **tenon** | **mosaic** |
| **triangular** | **obliquely** | **infinitely** |
| **bristles** | **resinous** | **microscope** |
| **external** | **cementing** | **prematurely** |
| **membranes** | **kneaded** | **ovipositor** |
| **marginal** | **receptacle** | **incision** |
| **diversity** | **hallowed** | **cavity** |

## Notes.

1. AMBOYNA, an island in the Indian archipelago, the most important and valuable of the Molucca Islands, belonging to the Dutch.

2. HOME, Sir Everard, an eminent surgeon, brother-in-law to the celebrated John Hunter, who wrote many valuable works on medicine and anatomy, and carried his researches even into the structural anatomy of insects. He practised in London for forty years, and held for a considerable period the post of President of the Royal College of Surgeons. He was born in 1756, and died in 1832.

3. LINNÆUS, or LINNÉ, Carl von, a Swedish naturalist, the most celebrated of his time, was born in 1707, and died in 1778. He was chiefly eminent as a botanist, and invented the famous system of botany which bears his name.

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## Exercise in Dictation—IV.

Fill a wine glass to the brim with water, and cover it with a piece of writing paper, then place the palm of the hand over the paper, so as to hold it even, and turn up the glass, when, although the hand be removed, the water will not run out. This effect is wholly produced by the upward pressure of the external air upon the surface of the paper.

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## PART III.—ORGANS OF SENSATION: HAIRS AND SPINES: ORGANS OF RESPIRATION.

### GLOSSARY OF SCIENTIFIC TERMS, &c.

**lobes**...*divisions of the lungs, brain, &c.* [Gr. LOBOS, a division.]

**an-al′-o-gous**........*possessing similarity or likeness; agreeing in certain respects.* [Gr. ANA, up to; LOGOS, proportion or relation.]

**tu′-ber-cles**........*small knobs rising from the surface in the form of pimples.* [Lat. TUBERCULUM, a little swelling, from TUMEO, I swell.]

**gang′-li-ons**...*knots or enlargements in the course of a nerve.* [Gr. GANGLION, a knot.]

**pa-ra-lyt′-ic**.....*afflicted with paralysis, or loss of power in any part of the body.* [Gr. PARA, beside ; LUO, I loosen; as if it were a loosening of the muscles.]

**func′-tions**...*duties, offices, employments, powers.* [Lat. FUNGOR, I perform or discharge ; participle, FUNCTUS, discharged.]

**sen-sa′-tion**...*feeling, perception by organs devoted thereto.* [Lat. SENTIO, I feel.]

**vig′-or-ous**.. *strong, lusty, full of strength.* [Lat. VIGEO, I am lively or strong.]

**dis-sec′-tion**...*the act of cutting into pieces or separating organic structures with the knife.* [Lat. DIS, apart or asunder ; SECO, I cut.]

**cat′-er-pil-lar**...*the grub of a butterfly or moth that lives on the leaves of plants..* [Old Eng. CÀTE, food ; PILLAR, a robber, from its stripping the trees for its food.]

**min′-i-a-ture**.....*on a small scale.* [Literally a painting in vermilion, from MINIUM, vermilion.]

**fil′-a-ments**......*substances resembling threads in form, fibres.* [Lat. FILUM, a thread.]

**es-sen′-tial** .....*absolutely necessary.* [Lat. ESSENTIA, essence.]

**spi′-ra-cles** ..*air passages or breathing holes.* [Lat. SPIRACULUM, an air passage, from SPIRO, I breathe.]

**di-ver′-ging**..*tending outwards from a common centre, or in different directions from a common point.* [Lat. DIS, apart ; VERGO, I bend or incline.]

**buoy′-ant**...*light and able to rise to the surface, like a buoy.* [Dutch BOEY, a chain or fitter, because casks or light substances used as buoys or marks are kept in their place by a chain or rope.]

**tra′-che-a**...*the windpipe or passage which conveys the air to the lungs, so called because of its roughness, being composed of rings of hard gristle.* [Gr. TRACHŪS, rough.]

**car-ti-la′-gi-nous**......gristly, formed of gristle. [Lat. CARTILAGO, gristle.]

*Organs of Sensation.*—The existence of a brain in insects has been denied, but they have certainly a part analogous to this important organ, in its situation, and in its sending forth nerves to the principal organs of the senses. From this, which consists of two lobes, proceeds the spinal marrow—a cord which is sometimes single, but usually double, uniting at intervals, expanding into several knots or ganglions, each of which may be considered in some degree as a centre of vitality, or little brain.

The nerves of insects, as of other animals, are white filaments running from the brain and spinal marrow to every part of the body.

In the nervous system of insects there is, however, great variety, and a gradual change takes place in it when insects undergo their metamorphoses, doubtless that it may be adapted to the altered functions of the animal in its new stage of existence.

In animals with warm blood sensation travels by means of the nerves and spinal marrow to the brain, where also all its perceptions terminate; and if the communication be cut off at the neck, the whole trunk becomes paralytic. But if the heads of insects be cut off the remainder of the body will continue to give proofs of life and sensation longer than the head. Both portions will live; but the largest will survive the longest, and will move, walk, and occasionally fly, at first almost as actively without the head as when united to it. If one insect be cut in two the halves will live and appear vigorous, even for a fortnight afterwards; and what is more remarkable, the tail part always survives the head two or three days. Thus the spinal marrow, as well as the brain of the insects, is concerned in sensation.

In their movements we observe the union of instinct and the senses. When a bee flies to a field or a garden, its senses direct it to the flowers, and enable it to discover the treasures of which it is in search; and then its instinct teaches it to imbibe the nectar, and load its hind legs with pollen; and on its return they are still in operation. The organs of sense are manifest on dissection, but what is the power which directs their employment?

*Hairs and Spines.*—Many of the larvæ or grubs are quite naked, but a very considerable number are clothed with hairs or bristles, and some have their skin beset with spines, or a mixture of spines and hairs. The hairs of the caterpillar of the great goat-moth are hollow, though not to the point, and it may be so in other cases. They are set in a ring or very short cylinder, raised a little above the skin. The hair passes through the ring, and appears to be rooted in a very soft substance; which clothes the skin

within, and on which the nerves form a tissue, like a small net.

The variety in the hairs of insects is indeed most amazing. Some have merely a few, short, scattered, and scarcely to be seen except through a glass; other species are covered with down, more or less thick. Sometimes the hairs seem to issue from *tubercles* or pimples, like little streams from the rose of a watering-pot, and partly or wholly concealing the body; and in one case each tubercle has but six hairs diverging like a star, while the chief part of the body appears naked. Some point to the tail, like the quills of a porcupine; others are directed downwards, some go both ways, and another variation is that the hairs of half the tubercle are very long, while those of the other half are very short and even of a different colour. In the larvæ of tusseh moths, the hairs on one part of the back resemble so many brushes, while on others they are like a camel-hair pencil.

Several insects are feathered like birds. One has three tubercles in each segment of the body, like so many little blue beads, from each of which proceeds a long black plume; but the most remarkable larvæ for the shape of its hairs has them all rough with small points, and moreever six long tufts, which, when alarmed, it erects as a porcupine does its quills; each hair being formed of a series of little conical or sugar-loaf pieces placed end to end, the points of which are directed towards the origin of each hair, which is terminated at the other extremity by a large and long conical mass something like the head of a pike.

Some of these little creatures are furnished with spines, or long sharp points, which are hairy and hard, and so stiff as readily to pierce the skin, and in one species they are said to be as stiff as iron wire. Sometimes these are beset with hairs or shorter spines, which give them the appearance of plumes, and there are instances in which the side spines resemble the branch of a tree; thus the body of a small caterpillar brought from Brazil wears the appearance of a forest or thicket in *miniature*. From the spines of this species there issues in many cases a smaller and very slender hair-like spine, resembling a sting, which can raise

little white blisters on the skin when slightly touched. The caterpillar of a moth found in Australia darts out, it is said, from as many knobs in its back, eight bunches of little stings, with which it inflicts a very painful and venomous wound.

*Organs of Respiration.*—Air is essential to insects, but their mode of breathing is different from that of the higher animals. They have no lungs confined to a particular part, by which the whole of the blood is regularly exposed to the air that is received, nor do they breathe through the mouth, but through spiracles and vessels which, connected with these, are conducted to every part of the body. The construction of these is most wonderful and admirable.

The little wriggling, worm-like animals, sometimes seen in tubs of rain-water, ascending to the surface, remaining there awhile, and then sinking to the bottom, are the grubs of some species of gnat, which are furnished with a very singular organ. The grub is tunnel-shaped (Fig. 1), and ends in five points like a star, and by this it is usually suspended at the surface of the water, and preserves its communication with the atmosphere. When the animal is disposed to sink, the points or rays of this part are used to close it, and to cut off this communication. When it is immersed, a globule of air remains attached to the end of the tube, so that it is lighter than the water, and requires some effort to reach the bottom; but when it wishes to rise, it has only to unclose the tube, when it easily ascends to the surface, and remains there for any length of time.

**Fig. 1.**

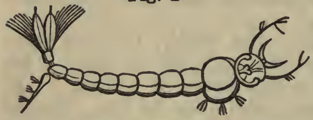
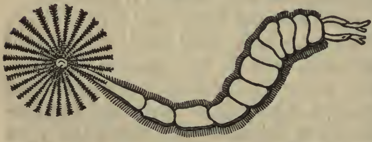


**Fig.**



The grub of the chamelion-fly (Fig. 2) has a breathing organ, resembling, in some degree, the arms of what are called sea-anemones. The last joint of its body is very

long, and ends in an orifice (to receive the air), which is surrounded by a circle of about thirty diverging rays, consisting of beautifully-feathered hairs or plumes. These are so prepared as to repel the water, in order to suspend the animal by its tail at the surface, and preserve a constant access of air. When it sinks it turns these hairs in, and shuts the orifice, carrying down with it an air-bubble that shines like quicksilver, and which, it is supposed, enables it again to become buoyant when it wants to breathe.

Some insects appear to extract air from the water, and for so doing are furnished with organs analogous to the gills of fishes ; but the process in them must be different, as they have no circulation. The first approach to this structure is presented by the pupa or chrysalis of a gnat *(Chirinomus plumosus)*, for on each side of the trunk it has a pencil consisting of five hairs elegantly feathered, which, when they diverge, form a beautiful star. It is also furnished with a fan-shaped pencil of diverging hairs.

About the month of April, if the weather be tolerably mild, a little merry creature may be seen gamboling on the surface of still water. After retiring in the autumn, and reposing in the mud at the bottom, it awakens in the spring and commences its sports. Fond of society, small parties of ten or a dozen may be seen when the water is particularly tranquil, and here they harmoniously circle round each other, every one keeping his place, and moving so lightly as only to form faint and transient circles on the surface. If parted by accident, they are soon associated again, and appear in one pool like so many little families, neither uniting nor contending ; and as Kirby says, "covered with lucid armour, when the sun shines they look like little masses of silver or brilliant pearls." These are provided with several long, hairy, slender organs, through each of which an air-tube passes ; in some instances the organs have much the appearance of gills, varying in number, but especially in form, in which respect they are sometimes very beautiful.

The internal organs by which the air received is distributed are full of wonder. The structure of the trachea of the cossus, for example, is admirably adapted to its

purpose. Had its vessels been composed of membrane (a web of interwoven fibres), they could not possibly have been kept from closing; but this is guarded against, and the necessary tension or stretching of the tubes provided for by the intervention of a corkscrew-like cartilaginous or bony thread. Thus, however small the vessels, or violent the contortions of the insect, they are always sure to remain open. The two tracheæ, moreover, give birth to two hundred and thirty-six tubes, and adding the smaller ones into which they ramify, have, in fact, 1,004 branches. These are necessary, for they are not only carried along the intestines and spinal marrow, penetrating and filling every ganglion or knot, but they are also distributed to the skin and every organ of the body, and accompany the most minute nerves through their whole course! What a display is here of the power and goodness of God!

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## PART IV.—DIGESTION AND SECRETION—BLOOD-VESSELS—ORGANS OF MOTION—MOTION.

*Digestion and Secretion.*—The structure of the alimentary canal in insects is wonderfully diversified. Not only are differences discoverable as we pass from family to family and from species to species, but the same individual will often be found to have a canal quite different, according as it is examined in its grub or perfect state.

All these variations exactly accord with the temporary or constant mode of life of the creatures in whom they appear. "Thus," says Cuvier, "the voracious larvæ or grubs of the scarabei and butterflies have intestines ten times as large as the winged and sober insects, if we may use such an expression, to which they give birth."

In two beetles which have been examined a remarkable difference has been observed. In the one there is no crop or gizzard, but the stomach is fringed on each side, and there are three pairs of bile vessels; while in the latter the gullet is dilated into a crop which includes a gizzard, in which the Divine wisdom is singularly apparent; for although so minute as scarcely to exceed a large pin's head

in size, it is stated to be provided internally with more than four hundred pairs of teeth moved by an infinitely greater number of muscles. The object of this extraordinary structure is the comminution, or reducing to powder, of the timber which this beetle has to perforate and probably devour. Its stomach has only two pairs of bile vessels.

Insects are also furnished with organs of secretion, which in general are membranous vessels that float in the blood or nutritive fluid, and secrete from it silk, saliva, jelly or gluten, varnish, scent, and poison. A brief description of one of these must suffice.

Goldsmiths or gold wire-drawers have iron plates pierced with holes of different sizes, and they draw gold and silver wire first through the larger and then through the smaller, according to the fineness that is required. Now the silkworm has under its mouth just such an instrument, having a pair of holes which are united in one on the outside. This is connected with the part that provides the silk, and which is formed of two long floating twisted tubes, growing slender towards the head of the insect, where they unite to form the spinneret which renders the silk. The length of these vessels depends on the quantity of silk wanted by the insect ; those of the silkworm are about ten inches long, while those of the cossus or larva of the goat-moth are little more than three inches. The silkworm fixes the first drop of gum that issues from these vessels, through the holes just mentioned, where it pleases, and then draws back its head or lets itself fall, while the gum, continuing to flow, is drawn out and lengthened. On being exposed to the air it immediately becomes dry and acquires consistence and strength. And most wonderful it is that she is never deceived in adjusting these openings, or in calculating the proper thickness of the thread, but always makes its strength proportionable to the weight of its body. The thread varies considerably in colour and texture, and sometimes resembles cotton or wool. In spiders it is much more soft and tender than that of other spinning insects.

A remarkable gnat actually carpets its paths and place

of rest with something between silk and varnish, and this it spins, not in a thread, like the spider and the silkworm, but in a broad ribbon.

*Blood Vessels.*—As "the blood is the life," so it may be expected to appear, in some way or other, throughout animated nature. There is not, however, in all cases, a real circulation. If, for instance, the back of any smooth caterpillar, with a transparent skin, be attentively examined, an evident pulsation will be perceived, as though a fluid were pushed along a narrow tube at regular intervals towards the head. Dissection, too, has proved that most insects have such a tube, placed immediately under the skin, and furnished with numerous air-vessels; and that this contains a fluid propelled in regular pulsations of from twenty to a hundred per minute, varying as the weather is colder or warmer. In the cossus these pulses were observed to begin at the eleventh segment, and to pass from segment to segment till they arrived at the fourth, where they terminated. This vessel Kirby describes as "the first step towards a heart." The fluid it contains is very abundant; in the animal it resembles water, but when collected in drops it becomes more or less yellow, and even orange; and when examined under a microscope it appears filled with a prodigious number of transparent globules, of incredible minuteness. The dispersion of this fluid appears to be universal, so that all the parts and organs contain it in a greater or lesser degree; and in many insects, if an antenna or a leg be broken, a drop of fluid flows out at the wound. And as manifest are the wisdom and goodness of the beneficent Creator in the fact observed by Cuvier, that as the blood for want of a circulating system is not able to seek the air, the air goes to seek the blood!

Spiders and scorpions have, however, circulating vessels. The heart of the former is a long dorsal vessel, as in insects, but supposed to be confined to the abdomen. On each side of the heart of the latter are vessels which may be assimilated to veins, while others cross them, and are the arteries.

*Structure—Motion.*—The muscles are the organs of

motion, being endowed with a remarkable, though inexplicable power of contraction. Each of them consists of minute fibres or threads, made as it were into a bundle. Their origin in the higher animals is from the blood, but in insects they are derived from a certain accumulation in the larvæ as a store of nutriment for the development and growth of the organs of the perfect insect while in the pupa state. The blood in which the different organs float that is not required for their nutriment is supposed to be expended in its formation. In the pupa of the cabbage-butterfly, a naturalist observed that this substance first assumed a fine flocky appearance and a blue-green colour, and that from it were produced tender bundles of muscular fibres, extending in various directions, the substance itself decreasing in proportion as they were formed.

The muscles of insects vary in shape; their ordinary colour is white, but it is said that those for flight differ from the rest by being of a deeper and reddish colour. In general they may be regarded as divided into primary and secondary; the primary being the muscles by which the principal movements of any organs are effected, and the secondary the cause of subordinate movements. Almost every muscle has its antagonist, the action of which is in an opposite direction; so that when it is equal the organ to which they are attached remains without motion; but when that of one preponderates, a proportionate movement takes place.

Lyonnet counted the muscles contained in the body of the caterpillar of the cossus. He found in the head 228, in the body 1,647, and enveloping the intestines no less than 2,186; which, after deducting 20 that are common to the gullet and the head, gives a total of 4,061. Only 529 have been counted in the human subject, so that this little creature has 3,532 muscles more than ourselves!—a fact which is no less curious than surprising.

The muscular power of insects is indeed extraordinary. Some can leap two hundred times their own length; and Bradley asserts that he has seen a stag-beetle carry a wand half a yard long and half an inch thick, and fly with it several yards. Others can resist pressure in a wonderful

degree. One, for instance, an inhabitant of muddy pools, has been occasionally taken up with the water used in paper-making, and, according to Linné, has resisted without injury the immense pressure given to the surrounding pulp.

A quotation from the invaluable work of Messrs. Kirby and Spence may appropriately close this article : "It is fortunate that animals of a larger size, especially noxious ones, have not been endowed with a muscular power proportionable to that of insects. A cockchafer, respect being had to their size, would be six times stronger than a horse ; and if the elephant, as Linné has observed, were strong in proportion to the stag-beetle, it would be able to pull up rocks by the root, and to level mountains. But the Creator in these little creatures has manifested his almighty power in showing what he could have done had he so willed, and his goodness in not creating the higher animals endowed with power and velocity upon the same scale with that of insects, which would probably have caused the early desolation of the world that he has made. From this instance we may conjecture that after the resurrection our bodies, by a change in the structure and composition of their muscular fibres, may become fitted for motions and a potent agency of which we have now no conception.

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## Exercise in Meanings and Derivation.—IX.

*Divide and accentuate each word, and give its meaning and derivation.*

| | | |
|---|---|---|
| **alimentary** | **fringed** | **secretion** |
| **species** | **gullet** | **membranous** |
| **voracious** | **dilated** | **instrument** |
| **gizzard** | **comminution** | **consistence** |
| **circulation** | **beneficent** | **antagonist** |
| **segment** | **inexplicable** | **conjecture** |
| **globules** | **nutriment** | **propelled** |
| **universal** | **subordinate** | **prodigious** |
| **arteries** | **desolation** | **dispersion** |
| **larva** | **pulsation** | **assimilated** |
| **secondary** | **resembles** | **accumulation** |
| **noxious** | **minuteness** | **primary** |
| **transparent** | **dorsal** | **preponderates** |
| **abundant** | **contraction** | **resurrection** |
| **incredible** | **pupa** | **agency** |

## Notes.

1. BRADLEY Richard, a celebrated naturalist and botanist, who acquired a considerable reputation for his researches into the habits of insects. He was born in the latter part of the 17th century, and died in 1732.

2. CIRCULATION OF THE BLOOD.—This important fact was discovered about the year 1620, by Dr. HARVEY, a celebrated English physician. He observed, in the course of his anatomical researches, that the valves of the veins all opened towards the heart, but shut back so closely as to resist the return of fluid, or even of air, the other way. He at once decided that so remarkable a contrivance must have some use, and that that use was to admit the flow of blood in one direction, but resist it in the other. The veins then returned the blood to the heart, but through what channels did this fluid find its way, in the first instance, to every part of the body? To answer this question, Harvey opened an *artery* in the living body, and out gushed the blood. So far was satisfactory; the artery contained blood, but what course was it taking? He tied an artery, and it swelled at the side next the heart; therefore its blood was coming to it from the heart. He tied a vein, and it swelled at the side furthest from the heart; therefore its blood was returning towards the heart. He showed that an animal would bleed to death, either from an artery or a vein, which clearly showed their communication. Finally, he opened a cold-blooded animal, and observed the whole process which he had thus beautifully argued out. With the humility of a Christian, joined to the spirit of a philosopher, Harvey continued his investigations into the animal body; and his discoveries changed the whole science of medicine.

3. LYONNET, Peter, a Dutch naturalist, born at Maestricht, in 1707, died in 1789. He wrote several valuable works on entomology, the most important of which was that on the anatomy of the Cossus or caterpillar of the Goat Moth.

4. SPENCE William, a naturalist of distinction, who was part author with the Rev. William KIRBY of the "Introduction to Entomology," which is not only an exhaustive work on the subject, but a valuable contribution to natural science. He was born in 1780 and died in 1860. For careful and patient research these naturalists are unsurpassed, except, perhaps, by the Swiss, Huber, who, although blind, contrived to write so admirable a work on the habits, etc., of bees.

## THE TEA-KETTLE AND ITS TEACHINGS.

### Glossary of Scientific Terms, &c.

**mon-ot′-o-nous**......*consisting of a single tone or sound, unvarying.* [Gr. MONOS, alone ; TONOS, tone.]

**re-flec′-tion**......*attentive consideration, careful thought, the binding of one's mind on a subject.* [Lat. RE, back ; FLECTO, I bend.]

**sci-en-tif′-ic**......*appertaining to knowledge.* [Lat. SCIENTIA, knowledge, from SCIO, I know.]

**con-fined′**..........*kept within certain bounds or limits.* [Lat. CON, together ; FINIS, a boundary or limit.]

**ex-pan′-sive**.... ...*tending to enlarge, diffusive.* [Lat. EX, out ; PANDO, I spread.]

**u-ten′-sil**.. ...*any vessel made for domestic purposes.* [Lat. UTOR, I use.]

**li-que-fac′-tion**...........*being brought into a fluid state.* [Lat. LIQUIDUS, liquid or fluid ; FACIO, I make.]

**pol′-ished**......*made bright by rubbing.* [Lat. POLIO, I make to shine.]

**trans-mit′-ted**...*sent through, caused to pass through.* [Lat. TRANS, through ; MITTO, I send.]

**ev′-i-dent**...........*clear, perceptible to the senses.* [Lat. E, from or out of ; VIDEO, I see.]

**po-ros′-i-ty**......*the quality of possessing pores or openings.* [Gr. POROS, a pore or opening.]

**ex-posed′**..........*subjected to, placed so as to be acted on by anything.* [Lat. EX, out ; PONO, I place ; participle, POSITUS, placed.]

**la′-tent**........*concealed, lying hidden.* [Lat. LATEO, I lie hid.]

**sta′-tion-a-ry**.........*standing still, keeping the same position.* [Lat. STATIO, a station or fixed position, from STO, I stand.]

**con-ver′-sion**......*change from one state or substance to another.* [Lat. CON, together ; VERTO, I turn ; participle, VERSUS, turned.]

**a-nom′-a-ly**......*something out of the common course, not according to rule.* [Gr. A, not ; NOMOS, a law.]

**in-vis′-i-ble**.........*unseen, not perceptible to the sense of sight.* [Lat. IN, not ; VIDEO, I see ; participle, VISUS, seen.]

**con-densed′**.........*thickened, made to occupy less space, as when steam by the action of cold is changed once more into water.* [Lat. CON, together ; DENSUS, thick.]

**mal′-le-a-ble**...... *soft, capable of being beaten out with a hammer without breaking.* [Lat. MALLEUS, a hammer.]

**car′-bon-ate**......*a compound formed by the union of carbonic acid with a base.* [Lat. CARBO, coal.]

The tea-kettle is found in every family in England. The bright copper tea-kettle, on a fancy trivet, hung upon the top bar of the stove, is frequently deemed an heir-loom. When the curtains are drawn, and the winter's frost drives every member of the family around the social hearth, with a thankful heart for the blessings of Providence, the familiar monotonous hum of the tea-kettle often soothes the mind to reflection. There may be several of our readers who have gathered round the hearth of a grandsire, and who remember, with delight, the serious or lively conversations which have there been indulged, by some who are still their warmest friends, and others who have entered another world. But among all the topics of conversation suggested by the appearance of the tea-kettle, the reader may not perhaps have thought that it illustrates many important scientific facts. It is stated that the use of steam as a mechanical power was first suggested by a tea-pot. The lid of the pot was observed to rise and give escape to the confined steam, and it was then thought that the expansive power of the same agent might be employed as a moving force.

The tea-kettle is invariably made of metal ; iron, tin, or copper is generally employed.

It is an utensil employed for the purpose of boiling water, heat being generally applied frcm a common coal-fire. Any substance is suitable for manufacturing into a tea-kettle that possesses the properties of conducting heat, of resisting liquefaction or combustion, and of holding a liquid.

There are some substances which possess the property of conducting heat in a much greater degree than others, and some bodies resist its progress altogether. A rod of earthenware and a rod of iron will be very unequally heated by precisely the same temperature. The metals are the best conductors of heat, and are, therefore, commonly employed in the construction of all utensils required for culinary purposes. From experiments it appears that silver is the best conductor ; but as it is a metal of too much value to be employed for domestic purposes, copper, which stands next to it in its power of conduction, or tin,

or iron, which follow in order, is used for such manufactures.

A bright polished surface, in a great measure, prevents the conduction of heat by reflection. The laws which govern the reflection of heat are the same as regulate the reflection of light. When light falls upon a piece of glass, it passes through it, or, at least, a large portion of that which falls upon it is transmitted. But when the glass is silvered on one side the light is reflected or thrown back, being unable to pass through the metal. So when heat is thrown upon a tin reflector, or any other polished surface, it is not conducted away, but thrown back again in a direction regulated by the form of the reflector. It would, therefore, consequently follow that water cannot be boiled so readily in a bright copper tea-kettle as in one that is not polished. But the influence of a reflecting surface is not so evident where the body is in positive contact with the source of heat. But if a mirror be placed at a distance from the fire, it will so radiate the rays of heat which fall upon it that it will acquire but little increase of temperature after a long exposure to the fire. This statement will show the necessity of having bright fire-irons, for they reflect the heat which falls upon them; whereas, if they were rough, they would acquire, in a little time, so high a temperature as to prevent their being touched.

It is hardly necessary to state that a tea-kettle, or any vessel intended to contain water for the purpose of boiling, must be made of some substance which is incapable of liquefaction at the temperature of a common fire. Lead would be an unfit substance, because it melts at a comparatively low degree of heat. Coal would be equally inapplicable, because it would suffer combustion; and various substances otherwise not improper must be rejected on account of their porosity.

From the statements already made, it will appear that there are many means by which heat may be communicated from one body to another by contact, radiation, or reflection. When it is to be conducted, the substance in contact with the source of heat should be of such a constitution as to receive the temperature applied without

losing its solidity, while, at the same time, it must resist combustion. Copper and iron, metals which cannot be melted at common temperatures, and which are excellent conductors of heat, are therefore employed for tea-kettles.

When the water contained in a tea-kettle has been, for a time, exposed to a high temperature, it becomes hot, and at last boils, a column of steam afterwards issuing from the spout. It may not be unworthy of our inquiry by what process this steam is formed.

The temperature of water under common pressure cannot be raised above 212 degrees of Fahrenheit's scale, which is always attached to English thermometers ; 212 degrees is the boiling point of water. Much heat may afterwards be communicated, but the sensible heat of the water is not increased, for all the additional heat that is communicated is expended in converting the water into steam. When heat is not sensible to the touch or thermometer, it is said to be latent ; some persons designate it constituent caloric. That the latter expression is very applicable may be proved by a simple experiment.

Take two small copper vessels ; in one place water and in the other ice, and let both be at the temperature of 32 degrees. In each of the vessels place a thermometer ; then plunge both vessels into a mercurial bath raised to a high temperature, or into a reservoir of water at 212 degrees, with the means of keeping it at nearly the same point. Immediately the vessels come in contact with the hotter body they begin to conduct the heat. The temperature of the water rises immediately, as seen by the thermometer in it, but the thermometer in the ice remains stationary. By the time the ice has melted the water will have a temperature of 172 degrees. It would, therefore, appear that heat equivalent to the temperature of 140 degrees has been communicated to the ice without raising its temperature. There is but one way of accounting for this fact, and that is, by supposing 140 degrees of heat to be necessary for the conversion of ice into water. So, when water is converted into steam, a certain amount of latent heat must be communicated. An ounce of water could not assume a

vaporous state without receiving as much heat as would raise its temperature, if sensible, 900 degrees. This will account for the apparent anomaly that it is colder during a thaw than in frosty weather. When the waters of our ponds, lakes, or rivers are frozen over, heat must be obtained from some source before the ice can be converted into water. In order, therefore, to effect this, heat must be taken from any substance which happens to be in contact. The temperature of the atmosphere is thus lowered to provide the constituent heat of the water during the thaw. So when water is vaporised the temperature of the substances in contact is necessarily lowered, their sensible heat being applied in a latent state by the fluid.

From this explanation it will appear that when the water contained in a tea-kettle or any other vessel has been raised to the boiling point, or 212 degrees, it cannot be made to rise higher, for all the heat afterwards communicated is spent in converting the water into vapour. This aqueous vapour is invisible, but when it issues from the spout of our tea-kettle it is condensed by the atmosphere, which is of a much lower temperature.

When the water is poured from the kettle into the tea-pot the source of heat is removed, and the water will begin to get cool, both by conduction and radiation. If the pot be made of a substance which is a good conductor, it will soon become as hot as the water it contains, and conduct away its heat to the atmosphere, and to any other body in contact with it. Such is the conducting power of the metals that, when a tea-pot is made of either of them, the handle is constructed of ivory, bone, wood, or some other badly conducting substance; or if a silver handle should be used, it is not connected immediately with the pot itself, but is separated by a small piece of a non-conductor.

Bodies are cooled by radiation as well as conduction. Heat is capable of radiation from a hot body; that is, of passing off in rays, or straight lines, without the interference of any conducting body, in the same manner as light radiates from one that is luminous. Those substances, therefore, which radiate heat are the most suitable to be employed for the manufacture of tea-pots.

The metals employed by the manufacturer for the construction of tea-kettles are copper and iron.

Copper is a metal of a beautiful red colour, and is so malleable that it may be beaten into thin leaves. As an article of commerce it is never quite pure, for it always contains a little charcoal and sulphur, and frequently lead and arsenic. It is commonly obtained from the copper pyrites, or yellow copper ore, which is a compound of copper, iron, and sulphur. It is found in the island of Anglesea, and in many parts of England, particularly in Cornwall. Copper mines have not been worked in England above 160 or 180 years. Before that period, whenever the workmen met with copper ore in the tin mines of Cornwall, they threw it aside as useless, no English miner at that time knowing how to reduce it to a metallic state. To chemical science, therefore, we are indebted for such an ample supply of this very valuable metal. The Romans, however, were acquainted with copper, for copper was the only money used by that people till the 485th year of their city, when silver began to be coined. In Sweden houses are covered with this metal.

When copper is exposed to the effects of atmospheric air and moisture for some length of time, it will be covered with a greenish-blue substance, which is the carbonate of copper. This substance is highly poisonous, and many persons have been killed by eating food prepared in vessels on which it had been formed. Too much care cannot be taken in keeping copper utensils perfectly clean; but it is worthy of remark that they may be used with perfect safety if this is attended to, for vegetable acids have no effect on the metal while hot. But to prevent a possibility of danger the inside of copper vessels is usually coated with tin.

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## Note.

For explanation of the terms Conduction, Radiation, Reflection, etc., see page 29; and also see the lessons given on these subjects in John Heywood's "Class Book of Modern Science."

## ON THE MECHANICAL PROPERTIES OF FLUIDS.

The science of the mechanical properties of fluids is called Hydrostatics. A fluid is a substance which yields to the slightest pressure. Fluids are divided into two classes, distinguished by the names of liquids and elastic fluids or gases; which latter comprehends the air of the atmosphere, and all the various kinds of air with which Chemistry makes us acquainted. We shall confine our attention at present to the mechanical properties of liquids or non-elastic fluids.

Water and liquids in general are little susceptible of being compressed, or squeezed into a smaller space than that which they naturally occupy. This is supposed to be owing to the extreme minuteness of their particles, which, rather than submit to compression, force their way through the pores of the substance which confines them, as was shown by a celebrated experiment, made at Florence, many years ago. A hollow globe of gold was filled with water, and on its being submitted to great pressure, the water was seen to exude through the pores of the gold, which it covered with a fine dew. But more recent experiments, in which water has been confined in strong iron tubes, proves that it is susceptible of compression.

Liquids are porous, like solid bodies, but the pores are too minute to be discovered by the most powerful microscope. The existence of pores in liquids can be ascertained by dissolving solid bodies in them. If we melt some salt in a glass full of water, the water will not overflow, and the reason probably is that the particles of salt will lodge themselves in the pores of the liquid, so that the salt and water together will not occupy more space than the water did alone. If we attempt to melt more salt than can find room within these pores, the remainder will subside at the bottom, and, occupying a space which the water filled before, oblige the latter to overflow. A certain proportion of spirit of wine may also be poured into water without adding to the bulk, as the spirit will introduce itself into the pores of the water. Fluids show the effect of gravitation in a more perfect manner than solid bodies; the strong cohesive

attraction of the particles of the latter in some measure counteracting the effect of gravity. In a table, for instance, the strong cohesion of the particles of wood enables four slender legs to support a considerable weight. Were the cohesion so far destroyed as to convert the wood into a fluid, no support could be afforded by the legs; for the particles no longer cohering together each would press separately and independently, and would be brought to a level with the surface of the earth.

This deficiency of cohesion is the reason why fluids can never be formed into figures or maintained in heaps, for though it is true the wind raises water into waves, they are immediately afterwards destroyed by gravity. Thus liquids always find their level. The definition of the equilibrium of a fluid is that every part of the surface is equally distant from the point to which gravity tends; that is to say, from the centre of the earth. Hence the surface of all fluids must partake of the spherical form of the globe, and be bulging. This is evident in large bodies of water, such as the ocean; but the sphericity of small bodies of water is so trifling as to render their surface apparently flat.

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## Exercise in Meanings and Derivation.—X.

*Divide and accentuate each word, and give its meaning and derivation.*

| | | |
|---|---|---|
| **hydrostatics** | **dissolving** | **spherical** |
| **compressed** | **cohesive** | **susceptible** |
| **porous** | **equilibrium** | **exude** |
| **gravitation** | **gases** | **occupying** |
| **definition** | **celebrated** | **deficiency** |
| **liquids** | **subside** | **bulging** |
| **minuteness** | **counteracting** | **trifling** |
| **considerable** | **independently** | **apparently** |

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## Note.

For detailed information on the "Pressure and Motion of Liquids," see John Heywood's "Class Book of Modern Science," chapter 3.

# FOSSILS AND CAVERNS.

## Glossary of Scientific Terms, &c.

**in-crus-ta′-tion**...*outer covering or shell.* [Lat. IN, over or upon; CRUSTA, the rind or shell of any substance.]

**con-vul′-sive**.. *attended with sudden and violent upheaving and shaking.* [Lat. CON, together; VELLO, I pluck out or tear away; participle, VULSUS, plucked away.]

**di-lu′-vi-al**...*pertaining to the flood or deluge.* [Lat. DILUVIUM, a flood, from DILUO, I wash away.]

**in-un-da′-tion**...*a flood caused by rain or outburst of water.* [Lat. IN, upon or over; UNDA, a wave.]

**tran-si′-tion**.. ...*passing from one state or stage to another.* [Lat. TRANS, across; EO, I go or pass.]

**py-ri′-tes**......*stone containing sulphur in composition with other metals, and so called because it sends forth sparks when struck against steel.* [Gk. PŬR, fire.]

**li′-as**......*argillaceous or clayey limestone underlying the oolitic formation.* The word is a corruption of LAYER.

**fer-ru′-gin-ous**....*impregnated with iron.* [Lat. FERRUGO, iron rust, from FERRUM, iron.]

**lig′-nites**...*coal-beds retaining the texture of the wood from which they were originally formed.* [Lat. LIGNUM, wood.]

**plas′-tic**......*easily wrought or moulded with the hand.* [Gr. PLASSO, I mould or form.]

**meg′-a-lo-sau′-rus**....*literally the "great lizard."* [Gr. MEGALOS, great; SAUROS, a lizard.]

**en′-vi-rons**......*neighbourhood, surrounding district.* [Fr. ENVIRONS, around.]

**am-phib′-i-ous**......*able to live on land and in the water.* [Gr. AMPHI, both; BIOS, life.]

**ich′-thy-o-sau′-rus**...*literally "the fish-like lizard."* [Gr. ICHTHUS, a fish; SAUROS, a lizard.]

**ple′-si-o-sau′-rus**......*literally akin to a lizard.* [Gr. PLESIOS, near; SAUROS, a lizard.]

**ce′-ta-ce-ous**......*of the whale-kind.* [Lat. CETE, a whale.]

**de-po-si′-tion**...*formation by settlement.* [Lat. DE, down; POSITUS, placed.]

**rhi-no′-ce-ros**......*an animal with a horn on its nose.* [Gr. RHIN, the nose; KERAS, a horn.]

**al-lu′-vi-al**...*washed down and deposited by water.* [Lat. AD, to; LUO, I wash.]

**mam′-moth**.........*an extinct species of elephant, so called by the Tartars, because they believed that it burrowed like a mole.* [Tartar, MAMMA, the earth.]

**con-cre′-tions**...*masses formed by parts growing together.* [Lat. CON, together; CRESCO, I grow; participle, CRETUS, increased.]

**sta-lac′-tites**...*pendants, like icicles, formed by the dripping of water containing carbonate of lime.* [Gr. STALACTOS, dropping.]

**per′-for-a-ted** .....*pierced by holes.* [Lat. PER, through; FORO, I bore.]

**se-pul′-chral**...*belonging to the tomb, or used for the purpose of burial.* [Lat. SEPULCHRUM, a tomb.]

**sta-lag′-mites**.......*projections from the floor of a cave, formed by the dripping of water containing carbonate of lime.* [Gr. STALAGMOS, a dropping.]

**her-biv′-or-a**...*animals which live on grass and plants.* [Lat. HERBA, grass; VORO, I devour.]

**ca-tas′-tro-phe**.........*disaster involving total ruin and destruction: a turning upside down.* [Gr. KATA, downwards; STREPHO, I turn.]

**hu′-mid**...*damp, moist.* [Lat. HUMIDUS, moist.]

Having furnished, in a previous lesson on "Geology and what it teaches" (page 59), a brief outline of the classification of the rocks which form the incrustation of our globe, we proceed to notice some of the most interesting circumstances which belong either to their contents, or to their general structure; and among the most interesting of these are fossils and caverns.

Reference has been already made to fossils, or remains which are found in the transition and other strata, and which are the evident result of convulsive changes on the surface of the globe, and particularly of the diluvial inundation recorded in the Holy Scriptures. The clay slates of Glaris, in Switzerland, are remarkable for their fossil fishes. They are found in almost every state and position. One of them, brought from the Monte Bolca, and deposited in the Parisian museum, belongs to the genus *blochius*, and did not, before it died, let go another fish which it is in the act of swallowing. Fossil fish are found in more recent formations, as well as in the transition strata, and chiefly in the following localities: Glaris, Mont Pilate, Eisleben, Monte Bolca, near Verona, at Grammont, near Beaume, in Mount Pietra-roya, in Italy, at Stabia, in the chalk beds of the Paris basin, St. Pierre, at Maestricht,

and those of Perigueux and Gravesend, and in the limestone quarries of Nanterre and St. Denis.

The organic remains of the lias limestone, which is nearly destitute of metallic or earthy minerals, except iron pyrites, are of an important character. The lias formation stretches across from the coast of the German Ocean, in Yorkshire, to the Channel in Dorsetshire. It usually forms broad plains at the foot of the oolitic range of hills. The whale tribe are discovered in these strata, or in the adjoining, as well as the greater quadrupeds; leading to the conclusion that not only the productions of the dry land, but the tenants of the ocean, have been changed by the revolutions of the globe. The bones of crocodiles are frequent in the more ancient secondary strata. In December, 1824, nearly a complete skeleton of a crocodile was found in a cliff at Whitby. The animal appears to have been about eighteen feet long. The crocodiles of Franconia are found in a calcareous stone, or gray-coloured marble, full of ammonites and other ancient shells. One of the most perfect fossil crocodiles is that of Sæmmering, at Monheim. The most interesting specimen, however, has been found at Caen, in Normandy. Below the chalk of the district and the ferruginous sand serving for its basis is a bed of blue marl, in which have been found, near Havre, bones of a crocodile. Under this stratum are vestiges of our Portland limestone, and lower down the madrepore bed called coral rag. Beneath this are beds, occasionally 300 feet thick, of another blue marl, analogous to that of Oxford, whence the crocodiles are dug. Several of these are unknown species. Crocodiles have also been discovered under the chalk formation in the ferruginous sands of England, in the chalk at Meudon, and over it in the lignites and plastic clay of several districts. There are crocodile remains in the Jura, in its most compact strata, accompanied by various species of tortoises. Sea-turtles occur in the quarries near Maestricht, intermingled with marine productions, and bones of gigantic lizards and crocodiles. The megalosaurus is a large species of reptile discovered in the oolite beds at Stonesfield, near Oxford, and analogous to some found in the environs of

Mannheim. Its thigh-bone is thirty-two inches long, which would indicate a total length of more than forty-eight feet. It was probably an amphibious animal. From the thigh-bone of another found in the ferruginous sandstone near Cuckfield, in Sussex, Buckland calculates the length of this reptile at from sixty to seventy feet. Two extraordinary sea-lizards have been discovered between Lyme and Charmouth, by Sir E. Home, called the ichthyosaurus and plesiosaurus. Their combinations of structure are truly surprising. In the former are seen a muzzle of a dolphin, teeth of a crocodile, head and breast of a lizard, four paws of a cetaceous animal, or paddles of a turtle, and the vertebræ of a fish. In the latter, with the same turtle paddles, is a lizard's head, and a neck like the body of a serpent. They belong to the more ancient secondary strata. Numerous interesting remains have been found in the chalk basins of Paris, London, and the Isle of Wight. Headen Hill, a part of Alum Bay, in the Isle of Wight, exhibits a natural section laid open since its deposition. It evidently contains the same description of strata, and in the same order, with the Paris basin, that is, alternate salt and fresh water deposits with shells. The blue clay about London is a marine deposit, being full of the remains of sea-animals. It is immediately beneath the gravel on which London is built. The bones of a rhinoceros, different from the three species of Africa, Asia, and Sumatra, have been dug out of the alluvial soil near Canterbury, and in many places of Germany, France, and Italy. The tapir, an animal peculiar to South America, has been found in a fossil state in different parts of Europe ; and the bones of the mammoth have been detected near London, Northampton, Harwich, Norwich, Salisbury Plain, and other parts of England, as well as in Ireland, Iceland, Sweden, Denmark, Russia, and various other countries of Europe. The teeth have been found both in North and South America.

The mountain limestone, and all the great calcareous formations, abound in vaults, caves, and fissures. These have always attracted attention on account of their beauty or grandeur, and, of late, because of the animal remains found in some of them. The sparry concretions which

they contain have obtained the name of stalactites and stalagmites. The former term is derived from a Greek word, which signifies distillation or dropping, and expresses the manner of their formation, Where water trickles through a chalky or limestone rock, it forms a drop, the moisture of which being soon evaporated, leaves a sediment of pure chalk or lime. Successive filtrations add to these accumulations of matter, which gradually descend into long conical projections from the roof of the cavern, forming precisely like the icicles which in winter are pendant from the eaves of cottages. These are called stalactites. When the supply of water is too rapid for evaporation, it, of course, drops on the floor, and thus by degrees rises upwards. The calcareous accumulations originated by this process are termed, for the sake of distinction, stalagmites. When the two unite, they frequently appear like a natural pillar supporting the roof of the grotto or cave. These are often extremely beautiful, especially when the incrustations are in a gypsum rock.

The celebrated labyrinth of Crete lies in the stratified limestone ; and through the whole island, says Tournefort, there is a world of caverns. Mount Ida is perforated in every direction.

The caverns of Germany are remarkable, of which the richest in body relics are those of Franconia. Those which encompass the city of Muggendorf prove that the neighbourhood was, for centuries, the resort of gigantic bears and other wild animals.

*Forster's Hohle* is distinguished for the beauty of its roof and the perfection of its stalagmite. Its height is from ten to thirty feet ; its greatest breadth ten yards. In the side vaults, which descend at an angle of $45_0$ into the main chamber, the stalagmite streams into the appearance of cascades of alabaster, waves of which seem to be rushing into the lake of the same substance below. The rocky roof is separated into partitions, so as to produce a resemblance of the richly fretted gothic roof of a chapel.

*Kuhl-loch* is nearly equal in size to a large church. On the floor animal dust is accumulated to the depth of six feet, mixed with teeth. Professor Buckland calculates that

this must be the remains of at least 2,500 bears, which, allowing a mortality of $2\frac{1}{2}$ per annum, must have been the inhabitants of the place for a thousand years.

*The cavern of Gailenruth* is the most famous for the quantity and high preservation of its bony relics. Here also have been found fragments of sepulchral urns, at least 800 years old. From the examination of M. Cuvier, it appears that the bones in this cave belong, in the proportion of three-fourths, to bears, of two or three species of the genus; next to which are those of the hyena, tiger, wolf, fox, glutton, polecat, or some kindred animal. He also observed some bones of the herbivora, particularly stags; and bones of an elephant's skull have been extracted.

The most remarkable natural excavations of this description in England are the following:—

1. *The Peak Cavern*, and the caverns in the limestone rocks of Derbyshire, which contain grottoes of great extent and beauty.

2. *Poole's Hole*, near Buxton. The entrance is narrow and low; but at a distance of thirty yards opens into a spacious vault, the end of which is 770 yards from the mouth. The ceiling and floor exhibit a great variety of chalky stalactites.

3. *Elden Hole* is an oval chasm, ninety feet long and nine broad. It contains beautiful sparkling stalactites, of a deep yellow colour.

4. *Yorda's Cave*, in the West Riding of Yorkshire, is curious in stalactites, which, from the shapes they have assumed, have acquired the fanciful names of the bishop's throne, the organ, &c.

5. The limestone of the *Mendip Hills* contains numerous caves and fissures, and in some places bones of the elephant, bear, and horse, have been found, which appear to have been drifted by the diluvial waters.

6. *Kirkdale Cave* was discovered in 1821. It is about twenty-five miles from York, in a bank about sixty feet above the bottom of a small valley. A person must enter it on his hands and knees. The passage contracts and expands from two to seven feet in breadth, and from two to fourteen feet in height. Its greatest length is 245 feet,

and there are several branch passages not yet explored. The floor has been covered with a bed of hardened mud, one foot in average thickness. The stalagmites formed upon it by filtrations from the roof spread over it like a thin crust of ice; in some cases where the incrustations were thick, they formed a bridge across the floor. The mud was found to be filled with fragments of bones of various animals, some of them appearing to have been gnawed by others. These seem to have been hyenas, while the bones on which they preyed belonged to the tiger, bear, wolf, fox, and weasel; the elephant, rhinoceros, hippopotamus, horse, ox, deer, rabbit, water-rat, and mouse; ravens, pigeons, larks, and ducks. The opinion of Professor Buckland and others is, that the cave at Kirkdale was the dwelling of hyenas during a long period, who dragged other animals into it, on which they preyed; and that the hyenas themselves, as they died or were killed by others, served for food. Hence, it appears, that there was a time when our wilds and forests abounded with animals to be seen at present only in southern or warmer latitudes, and that many generations lived in these regions. It is obvious, also, that a great catastrophe must have brought destruction upon them; and this catastrophe must have been a deluge which, gradually approaching, afforded an opportunity for the then living animals to escape from the cave—thus occasioning the absence of a perfect hyena skeleton in this singular depository.

7. *Kent's Cavern*, near Torquay, is a curious hollow in a limestone rock, about 600 feet in length, and varying in width from two to seventy feet; in height contracting and dilating from a few feet to six yards. It contains fossil bones of a description similar to those just mentioned, and buried in a similar mass of mud, covered with stalagmitic incrustation.

8. *The Grotto of Antiparos*, a small island in the Greek Archipelago, has long been celebrated for extent and beauty. There are two inscriptions on natural pillars near the entrance, with the names of several persons celebrated in Grecian history. The entrance is by a low arch, thirty feet wide, divided by the pillars just mentioned. A series

of descents, separated by level landing places, lead about half way down, when the explorer proceeds by rope or ladder along a gentle descent; at the bottom of which, on turning round a rock, he finds himself in a spacious hall, the dimensions of which are obscured by the humid exhalations. The sides and roof are covered by calcareous incrustations, forming stalactites or pillars rising from below; while several perfect columns reach to the ceiling, and are still in the process of formation. These depositions have assumed fantastic shapes, and the pure white spar catches and reflects the light of the torches, so as to fill the imagination with a scene of romantic grandeur. Some of the concretions form a kind of thin curtain which, when the torches are placed against it, is transparent. In the middle of the great hall is a large, fine stalagmite, more than twenty feet in diameter, and twenty-four in height, termed the altar, from the circumstance of the Marquis de Nointel, ambassador from Louis XIV. to the Sultan, having caused high mass to be celebrated in this grotto, in 1673. It was attended by 500 persons, and the place illuminated by 100 large wax torches; and 400 lamps burned in it day and night, for the three days of the Christmas festival. The length of the grotto is about 1,000 feet; the breadth of the hall 300 feet; the floor of the lowest part 254 feet below the surface of the earth. Many of the recesses have not yet been explored.

If our limits did not absolutely prohibit any further details of this description, the general interest of the subject would tempt us to prolong the present division. Enough, however, has been stated to promote inquiry and encourage research, and enough, also, surely, to excite in every reader new emotions of admiration, in contemplating the phenomena of nature.

## Exercise in Dictation—V.

If a ball of light wood be dipped in oil and then thrown into water, the water will recede, so as to form a channel round the ball: this is owing to the repelling force between the bodies, from which cause water cannot be mixed with oil, whatever attempts may be made to effect it.

## CLOCKS: THEIR ORIGIN AND INVENTION.

Though the necessity of having some measure and register of time must have been felt from the earliest ages, it was long before a judicious and effectual one was adopted. The natural divisions of day and night would readily present themselves as marking its flow; but the irregularity of their length would soon point out the need of some other criterion; and, besides, among all nations there have been considerable differences with regard to the commencement and termination of their days.

The beginning of the day was counted from sunrise by the Babylonians, Syrians, Persians, and Indians. The civil day of the Jews was begun from sunrise and their sacred ones from sunset. The Egyptians varied their mode in different provinces. The ancient astronomers reckoned from midnight, the modern from midday, or noon. The Mohammedans reckon from one twilight to another. The most curious method is that of the Italians. Their civil day commences at some point after sunset, and the time of noon varies with the season. At the summer solstice the clock strikes sixteen at noon, and nineteen at the time of the winter solstice; thus also the length of each day differs by several minutes from that immediately preceding or following it. This variation occasions a considerable difficulty in adjusting their time by clocks. It is accomplished, however, by a sudden movement, which corrects the difference when it amounts to a quarter of an hour; and this is done sometimes at the end of eight days, sometimes at the end of fifteen, and sometimes at the end of forty. Information of all this is given by a printed calendar, which announces that from the 16th of February, for instance, to the 24th, it will be noon at a quarter past eight, evening; from the 24th of February to the 6th of March, it will be noon at eighteen o'clock precisely; from the 1st of June to the 13th of July, it will be at half an hour after sixteen: and so on throughout the different months of the year. This absurd method still continues in use. It should be said that the Italians reckon the hours from one to twenty-four.

The subdivisions of the day have also been various. Morning and evening would readily occur, and the intermediate points of noon and midnight would soon be determined. Hence arose the method of the Jews and Romans dividing the day and night into four vigils or watches. It is uncertain at what time the farther subdivision of the day into hours first commenced. Moses appears not to have been acquainted with it, and therefore we may conclude the Egyptians were not. Herodotus states that the Greeks received it from the Babylonians. It is probable the division was used before the name of hour was applied to it. The Chinese have five watches in the night, which are announced by a certain number of strokes on a bell or drum. The ancient Tartars, Indians, and Persians divided the day into eight parts, each containing three hours.

The divisions of the day being determined, it soon became an object to announce them publicly. This was done among the Egyptians by priests, who proclaimed the hour as watchmen have done since. An instrument, however, became desirable to estimate the lapse of time. One of the first of these was the clepsydra, or water-clock, invented by the Greeks; but it is an inaccurate measure of time, varying not only with the quantity of water in the vessel, but with the state of the atmosphere. The gnomon, or sun-dial, was in early use. The time and place of its invention are unknown. The Jews are supposed to have received it from the Babylonians before the time of Ahaz, when we know that a sun-dial was already erected in Jerusalem (2 Kings xx., 11) B.C. 713.

It was long after the invention of sun-dials that mankind began to form any idea of clocks: nor is it well known at what period they were first invented. A clock was sent by Pope Paul I. to Pepin, king of France, which at that time was supposed to be the only one in the world. A very curious one was also sent to Charles the Great from the Khalif Haroun Alraschid, which the historians of the time speak of with surprise and admiration; but the greatest improvement was that of Mr. Huygens, who added the pendulum. Still, however, the instruments for dividing time were found to be inaccurate for nice purposes. The

expansion of the materials by heat and their contraction by cold will cause a very perceptible alteration in the going of an instrument in the same place at different times of the year, and much more if carried from one climate to another. Various methods have been contrived to correct this, which, indeed, can be done very effectually on land by a certain construction of the pendulum; but at sea, where a pendulum cannot be used, the inaccuracy is of consequence much greater; nor was it thought possible to correct the errors arising from these causes in any tolerable degree until the late inventions of Mr. Harrison in the construction of his timepiece. Other ingenious men have followed in the same useful art, and great improvements have therefore been made in chronometers.

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## Exercise in Meanings and Derivation.—XI.

*Divide and accentuate each word, and give its meaning and derivation.*

| | | |
|---|---|---|
| **register** | **publicly** | **information** |
| **judicious** | **gnomon** | **absurd** |
| **irregularity** | **perceptible** | **intermediate** |
| **criterion** | **pendulum** | **vigils** |
| **termination** | **astronomers** | **clepsydra** |
| **calendar** | **curious** | **inaccurate** |
| **announce** | **solstice** | **climate** |
| **precisely** | **variation** | **tolerable** |

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## Notes.

1. Harrison, John, was originally a builder, but having turned his attention to the construction of clocks and watches, became so skilful in horology that he effected many improvements in the mechanism of time-keepers, inventing the compensation or gridiron pendulum, and the going fusee, by which a watch continues to go while it is being wound up. He received a reward of £20,000 for making a chronometer sufficiently accurate in its movements to measure longitude at sea. He was born in 1693 and died in 1776.

2. Huygens, Christian, an eminent Dutch mathematician and astronomer, born 1629, died 1695. He invented the pendulum, improved the air pump, and published several works on astronomy and mathematics.

3. HAROUN, Alraschid, a celebrated Eastern caliph of the Saracens, who reigned from 786 to 809, and sent an embassy to Charlemagne, Emperor of the West, with several presents, among which was a fine clepsydra or water clock.

4. PAUL I. ascended the papal throne in 757. Pepin, king of the Franks, supported him in his quarrels with Desiderius, the king of Northern Italy. He died in 767.

5. PEPIN, surnamed the Short, was the first of the Carlovingian kings of France, having assumed the royal authority after dethroning and imprisoning Childeric III., in 750. He was the father of Charlemagne. He died in 768.

## Exercise in Dictation—VI.

Independent of the four stomachs, which are common to ruminating animals, camels have an additional bag, which serves them as a reservoir for water. This fifth stomach is peculiar to the camel, and is so large as to contain a considerable quantity. When the animal is pressed with thirst, and has occasion for moisture to macerate his food in ruminating, he makes part of the water rise into his stomach, or even as high as his throat, by the mere contraction of certain muscles. By this singular construction the camel is enabled to pass several days without drinking, and as neither the liquors of the body nor the juices of digestion can mix with it, the water remains fresh and limpid. Oriental travellers have sometimes found it necessary to kill their camels in order to obtain the water preserved in these receptacles.

## THE OCEAN.

### PART I.—ITS PURPOSES, SURFACE, AND EXTENT.

And thou, majestic main!
A secret world of wonders in thyself,
Sound His stupendous praise, whose greater voice
Or bids you roar, or bids your roarings fall.

THOMSON.

### GLOSSARY OF SCIENTIFIC TERMS, &c.

**un-fath′-om-a-ble**..*that which cannot be sounded, or of which the depth cannot be ascertained.* [Ang.-Sax. UN, not; FAETHM, to hold.]

**con-cav′-i-ties**...*deep hollows.* [Lat. CON, intensive; CAVUS, hollow.]

**ob-scure′**...*difficult to understand.* [Lat. OBSCURUS, dark.]

**mys-te′-ri-ous**......*secret, that which cannot be understood.* [Gr. MUSTERION, something hidden.]
**ex-hil-a-ra′-tion**...*joyousness, gladness, act of being cheerful.* [Lat. EX, intensive; HILARIS, cheerful.]
**ex-te′-ri-or**...*the outer part, outermost surface.* [Lat. EXTERUS, outward.]
**col-lec′-tion**...*a gathering together.* [Lat. CON, together; LEGO, I gather; participles, LECTUS, gathered.]
**su-per-fi′-ci-es**.......*the outer surface of any solid body.* [Lat. SUPER, above; FACIO, I make.]
**fer′-ti-li-zes**...*enriches, makes fruitful.* [Lat. FERTILIS, fruitful.]
**med-i-ta′-tion**.......*deep and earnest thought.* [Lat. MEDITOR, I think on.]
**con-tin′-u-ous**......*without a break or division.* [Lat. CON, together; TENEO, I hold.]
**in-ge′-ni-ous**...*clever, evincing talent, skilful in invention.* [Lat. INGENIOSUS, skilful.]
**im-per-cep′-tib-ly**.. ..*without being aware, without our being conscious.* [Lat. IN, not; PERCIPIO, I perceive.]
**ob′-late**...*widened out at the sides like an orange.* [Lat. OBLATUS, offered or brought against.]
**spher′-oid**...*resembling or approaching a sphere in form.* [Gr. SPHAIRA, a sphere, or round ball; EIDOS, form or shape.]

Of all natural scenes that presented by the ocean, on first beholding it, is perhaps the most mysterious and impressive. The emotion thus produced is peculiar and indescribable: a strange mixture of awe, and wonder, and exhilaration.

In obedience to the command issued by the Lord of all, "Let the waters under the heaven be gathered together unto one place, and let the dry land appear," the body of waters previously flowing over the general surface of the earth was, on the third day, collected together in portions only of the exterior plain, forming seas in those parts, and leaving the rest of the earth for habitable ground. Some parts of the globe must have been raised up in order to form concavities for the permanent reception of the waters, and this is evidently the form of the earth. Vast ranges of mountains and rocks are now seen standing in various regions as high above the common ground as the depths of the ocean seem to be below it. By this collection and disposition of the waters not only was a portion of the

earth's surface brought into the state of "dry land" for the habitation of man and innumerable other creatures, but the ocean itself answers various important purposes in the general economy ; as, 1. It forms a general communication between the different countries of the earth, more accessible and convenient than if the whole had been land. 2. By its constant motion it tends to preserve the air in a state of purity. 3. It is the great reservoir into which the lakes and rivers empty themselves, and from which is again drawn by evaporation that moisture which, falling in showers of rain, fertilises the earth, and supplies the waste of the springs and rivers. 4. In the production and sustenance of fishes, it supplies a considerable portion of the food of man ; and 5. In a moral and religious view it furnishes a magnificent illustration of the power and wisdom of the Almighty, and suggests many topics for serious and profitable meditation.

*Surface and Extent of the Ocean.*—Though, for convenience in arrangement and description, various names have been given to different parts of the ocean, there is, in fact, only one continuous fluid surrounding the land, all the gulfs and inland seas, and distinct oceans being branches or parts of the universal whole. It is, of course, impossible, from the irregularity of its shape, to determine the exact quantity of surface which the ocean covers, or the proportion which it bears to that of the whole earth. It cannot, however, be less than two-thirds of the whole ; in other words the surface of the water is twice that of the land. Some have supposed it to be as much as three-fourths of the whole ; but this is evidently too great a ratio—the truth perhaps may be between the two.

*Its Depth.*—It is as difficult to ascertain the depth of the sea as its superficies, both on account of the numerous experiments it would be necessary to make, and the want of proper instruments for that purpose. It has never been sounded, actually, to a greater depth than a mile and sixty-six feet, or 5,346 feet, though Mr. Scoresby supposes that he once reached 7,200. In many places it has been found unfathomable ; not that we are to suppose it to be really without bottom, but because though several very ingenious

methods have been contrived to reach it none of them have completely answered the purpose. We know, in general, that the depth of the sea increases gradually as we leave the shore; but how far this increase is continued we know not. The probability is that the bottom of the water is uneven, like the surface of the land, and therefore that the greatest depth of the ocean exceeds the greatest altitude of mountains, in about the same proportion as its surface is greater than that of the land. From our ignorance of the actual extent and the mean depth of the great body of waters, it is obviously impossible for us to calculate the actual quantity it contains; but perhaps our conception of its amazing vastness may be as correct and as striking from the general idea we form of it as it would be if represented in numbers, which, beyond a certain limit, are obscure, and require illustration by some other means. In attempting to calculate the quantity of water which all the rivers discharge into the sea it is requisite to employ one or more whose velocity and quantity are known. For this purpose the river Po, in Italy, has been made use of: its mean depth, mean breadth, and velocity being known, it is easy to compute the quantity it discharges in any given time; and it appears that this river requires twenty-six days to discharge a cubic mile of water into the sea. From the extent of country watered by this river and its tributaries, compared with the whole surface of the earth, it is supposed that all the rivers in the world discharge about forty-eight cubic miles in a day—a rate which would require many centuries to yield a body of water equal to that of the whole ocean. Still it may seem surprising that, though "all the rivers run into the sea," yet "the sea is not full," or even apparently enlarged in quantity. But the surprise will cease when we recollect that much more is taken from the sea by evaporation than all the rivers united pour into it; and this must evidently be the case, as, from the superior extent of the ocean, more rain falls upon it than upon the whole surface of the earth. The simplicity of this great process is astonishing, as well as its magnitude. By the action of heat and wind upon the surface of the water a quantity is raised imperceptibly into the air, to fertilise

the earth and nourish the vegetable kingdom. Much of it also falls down the hills and mountains to form rivers, which, carrying wealth and commerce along with them, flow again into the sea to repeat the same round of service.

The general level of the sea, if it were not for the action of external disturbing causes, would be the same everywhere at the same instant; and the figure assumed by the ocean would then be the true regular surface of our planet, an oblate spheroid. But it is evident there can be no general level of this kind, because the tide, at any given moment, is at very different heights in different parts of the ocean, and because the wind is continually disturbing it. In gulfs and inland seas the level of the water is usually more elevated than in the ocean. The French engineers, when in Egypt, observed that the waters of the Red Sea on the east side of the Isthmus of Suez, were 32½ feet higher than those of the Mediterranean on the opposite shore. Baron Humboldt found that the waters of the Gulf of Mexico are from twenty to twenty-three feet higher than those of the Pacific on the other side of the Isthmus of Darien.

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## Notes.

1. HUMBOLDT, Frederick Henry Alexander von, the greatest naturalist of his time, was born in 1769, and died in 1859. He was a German, or rather Prussian, having been born at Berlin. He travelled through South America, and visited almost every part of the world. He wrote many works on natural history, &c.; but the most important of these is "Kosmos," his best and latest, in which "he contemplates all created things as linked together, and forming one whole, animated by internal forces."

2. SCORESBY, William, was first a sailor and afterwards a clergyman. He was born at Whitby, in 1790, and died in 1867. He made many voyages to the Arctic regions, and explored a great part of the coast of Greenland. His researches in natural history, physics, and meteorology were considerable, and his experiments with he magnet led to precautions being taken to secure the compasses of iron ships from derangement by means of the magnetic action of the material from which they are constructed.

## Part II.—Its Colour, Saltness, Temperature, Icebergs, and Luminousness.

*Its Colour.*—The general colour of the ocean is a deep blueish green, which becomes clearer towards the coasts. This colour is thought to arise entirely from the same cause as the azure tint of the sky. The rays of the blue light being the most refrangible, pass in the greatest quantity through the water, which, on account of its density and depth, makes them undergo a great refraction. The other colours exhibited in parts of the sea depend on causes which are local, and sometimes deceptive.

The Mediterranean in its upper part is said to have at times a purple tint. In the Gulf of Guinea the sea is white; around the Maldive Islands it is black; and in some places it has been observed to be red. These appearances are probably occasioned by vast numbers of very small marine insects, by the nature of the soil, or by the infusion of certain earthy substances in the water. The green and yellow shades of the sea proceed frequently from the existence of marine vegetables at or near the surface.

*Its Saltness.*—This property of sea-water is universally known, being observed to exist, with some variations, at all times, and in every part of the ocean. The cause of this saltness has been made matter of inquiry, and even of dispute: the true solution of the question is, that it hath pleased God to make it so. The obvious advantages of it are the preservation of purity in the water, and its greater capacity to sustain vessels navigating upon it. The salt, which is the same as that in common use (muriate of soda), may be separated by boiling, or evaporation in the air, and for salting meat is preferred to the salt of springs. In general the saltness of the sea is less towards the poles than near the tropics; but the difference is slight, and probably not well ascertained. The proportion of salt in water taken up at different places varies from 3·125 to 4·50 per cent of the weight of water; that in south latitudes contains rather more than such as has been tried in north latitudes, and generally the sea is less salt at the surface than towards the bottom. The violent tropical rains

diminish the saltness where they fall, especially near the coast, where great quantities of fresh water are brought down by the rivers. The Baltic is at all times less salt than the ocean; and when a strong east wind keeps out the North Sea, its waters are said to be almost fit for domestic uses. Springs of fresh water sometimes rise up in the sea, as far as two or three miles from the land. That bodies are more buoyant in the sea than in other water, is well known; and this is to be ascribed to its greater specific gravity, which is to that of distilled water as 1·028 to 1·000; that is to say, the former is twenty-eight parts in a thousand heavier than the latter.

There is a bitter taste united with the saline in sea-water. This bitterness does not appear to reach beyond a certain depth, and is probably occasioned by vegetable and animal matter held in a state of decomposition.

*Its Temperature.*—This is much more constant in the ocean than in the atmosphere. Water being a bad conductor of heat the changes are less sudden, and by no means so extensive. The temperature never exceeds eighty-six degrees of Fahrenheit's thermometer. Banks and shallows diminish it, but currents are much more effectual in modifying the temperature both ways. The stream which sets into the Gulf of Mexico is much warmer than the adjacent parts of the sea; the current of Chili is just the reverse. Within the tropics there is no sensible difference in north and in south latitudes; but in high latitudes the sea is colder in the southern than in the northern hemisphere; and the ice extends farther from the south than from the north pole. In middle latitudes, the spaces between clusters of islands, where the action of the waves is more confined and the water of less depth, are more readily frozen than the open sea. Hence it is that the Baltic is often rendered unnavigable by the ice, while the main ocean in the same latitude is always open. The Gulf of Bothnia in severe winters may be passed in sledges, though the width is more than a hundred miles. The quantity of ice towards the pole for a long time baffled all attempts to discover a north-west passage from the Atlantic to the Pacific Ocean. Few things in nature

are more striking or more sublime than the scenes presented in a polar region : the ice assumes a great variety of shapes and appearances, sometimes showing an aspect of beauty, and at others of " majestic desolation." The vast and thick sheets are called *fields*, and are so extensive that their boundaries cannot be seen from the mast-head : one of these fields even connects Asia with America. Smaller sheets are termed *floes*.

*Icebergs* are islands of frozen water, considerably elevated, generally perpendicular on one side, and sloping gradually down on the other. They are sometimes 200 feet in height. Floating ice has about one-seventh of its thickness above water ; but icebergs are sometimes aground, and therefore show a greater proportion of their height. They are formed either by the pressure of large masses of ice upon each other by winds and currents, or are detached, by their own weight or the action of waves, from the vast glaciers which abound in Greenland and Spitzbergen. It is to be observed that sea-water requires a lower temperature, by three degrees and a half of Fahrenheit, to freeze it than is necessary for common water. The masses of ice which have been frozen together gradually separate as summer advances, and clear spaces of water are left ; but these begin again to be frozen over as early as the end of September.

*Its Luminousness.*—The surface of the ocean often appears bright and shining at night, especially when the waves are unusually agitated by a storm. The motion of the vessel also contributes to this effect, which is often observable near its sides as it passes along, and especially in its wake, or the part left behind in its passage. In the tropical seas this phenomenon is the most brilliant, and the mountainous waves appear as if crested with fire. The cause of these appearances is not satisfactorily known. Some have ascribed them to electricity, others simply to friction ; some to luminous insects, and others to putrefaction, which gives to certain substances phosphoric qualities. It is probable that all these causes may have a share in the effect, operating either singly or in conjunction ; but the most usual and effective is supposed to be the last.

## Exercise in Meanings and Derivation.—XII.

*Divide and accentuate each word, and give its meaning and derivation.*

| | | |
|---|---|---|
| **refrangible** | **currents** | **saline** |
| **infusion** | **unusually** | **diminish** |
| **marine** | **electricity** | **adjacent** |
| **disputes** | **putrefaction** | **majestic** |
| **solution** | **phenomenon** | **desolation** |
| **poles** | **deceptive** | **glaciers** |
| **tropics** | **obvious** | **agitated** |
| **decomposition** | **preservation** | **friction** |
| **modifying** | **capacity** | **conjunction** |
| **baffled** | **navigating** | **crested** |
| **sublime** | **distilled** | |

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## Part III.—Its Incessant Motion and Currents.

I love to wander on thy pebbled beach,
Marking the sun-light at the evening hour,
And hearken to the thoughts thy waters teach—
Eternity, immensity, and power.

*Incessant Motion of its Waters.*—They are never at rest: from year to year, and from age to age, they are laving the shores, or whirling in eddies, or rolling in billows, or rising in invisible vapour to form clouds, which water the earth. How far its movements descend it is difficult to say; but from the rotation of the earth, in conjunction with other causes, it is probable that they extend in some measure to its lowest depths, and in various degrees through its whole volume. At its surface, and near it, we know, from universal testimony, that it is in ceaseless agitation.

There are at least three kinds of motion in the sea: 1. The agitations produced on its surface by the action of winds. 2. Currents, both perpetual and shifting, which arise from various causes, and flow at different depths and in different directions. 3. The periodical and reciprocating motions, called tides, which result from the attraction exercised on the water by the sun and moon. Also, some have supposed a general motion of the whole mass, unconnected with any of the preceding, but for which they have been unable to account.

1. It is well known that the particles of a fluid press equally in all directions; and hence it follows that when a portion of the surface of the water is displaced by a wind,

the adjoining water rushes in to restore the equilibrium or balance which has been destroyed. In this manner waves are formed. When a violent impulse has thus been communicated, the waves continue in motion for some hours after the gale has subsided, on the same principle as the pendulum continues to swing for some time after it has been set in action. The agitation of the waves extends but a little way below the surface of the water ; and those who have had much experience in diving say that, in the roughest weather, it is calm at the depth of ninety feet.

2. Currents may arise from a gale of wind ; from a difference in temperature or saltness between two parts of the sea ; from the melting of the polar ice, or from inequality in evaporation. The most remarkable currents are those which continually follow the same direction. One sets regularly from each of the poles towards the equator ; and between thirty degrees of the line on either side a general movement is observed in the ocean, in a direction nearly from east to west. The polar currents are shown by the floating of masses of ice from the frigid to the temperate regions. It was the opposition of one of these that prevented the success of Captain Parry's endeavour to reach the North Pole. The party found that, as they advanced over the ice, they were drifted southward faster than they travelled northward. These polar currents may be ascribed, in great measure, to the centrifugal force resulting from the earth's rotation, and in part also to the circumstance that the water towards the poles, from its lower temperature and its being less attracted by the heavenly bodies, is heavier than that of the tropical regions, where, besides, the evaporation is greater. The tropical current also may be accounted for by considering that the polar waters pass from regions where the rotatory motion is very slight to those where it is exceedingly rapid ; and they are accordingly left rather behind, and appear to have a general movement from east to west—an effect which is much assisted by the trade winds. Various modifications, however, take place in this grand movement of the ocean, in consequence of the obstacles presented by the land to its free progress ; and hence other and contrary currents

are produced, which are often extremely dangerous, and require the greatest skill to avoid them, or to profit by their force. Beside the main currents, whether constant or variable, which are observed on the surface of the ocean, there are probably under-currents flowing in a different and even in an opposite direction. It has been thought that the Mediterranean, which has a strong and constant flow through the strait of Gibraltar, sends back a portion of its waters into the Atlantic by a concealed current. It is not unusual to see currents passing along, side by side, in a contrary direction to each other; and when two opposite currents of nearly equal force meet one another, they sometimes, in narrow channels, turn upon a centre, and assume a spiral form, giving rise to eddies, or whirlpools, of which Charybdis, between Italy and Sicily, and the Maëlstrom, off the coast of Norway, are known examples.

3. The tides furnish a subject of most interesting consideration. Their chief cause is the difference of the moon's attraction on different parts of the earth at the same time. As the earth turns round on its axis, each meridian passes under the moon in 24 hours 50 minutes. The waters below the moon are attracted in a greater degree than the earth's centre and mass, and the earth itself is attracted more than the waters on the side furthest removed from the moon. Two tides are thus produced, one on each side of the earth, while intermediate between these two points the waters from the accumulation that is caused there by the attraction of the moon and the consequent withdrawal of the waters, from the points midway between them, are as much depressed below the surface as the tides are elevated. Thus round the earth from east to west there are at the same time two places of high water and two of low; and if there was no land to cause interruption, these four points would move west round the earth in 24 hours 50 seconds, there being alternately a flow for a fourth of the time, and an ebb for a fourth of the time. The sun has about $2\frac{1}{2}$ times less effect on the tides than the moon. At new and full moon, when the attraction of the sun and moon act in the same line, we have the spring or highest tides—these tides

being highest when the sun and moon are nearest the earth. The neap or lowest tides are at the moon's first and third quarter, when the sun's attraction acts on the waters in a line at right angles to the direction in which the attraction of the moon is exercised.

The wonders of the ocean are not confined to its surface, or to small distances below it, but abound also in its very deepest recesses. In "the great and wide sea," there "are things creeping innumerable, both small and great beasts." Fishes of all kinds and magnitudes, from the leviathan of the deep to the smallest of the finny tribes; reptiles, and various orders of animated existence, people its domain; and though multitudes have been taken and examined, it is probable that multitudes remain which the penetrating curiosity and the utmost art of man have not yet been able to discover. Marine plants also, of great variety and abundance, are known to exist at the bottom of the ocean; and such as have been brought to light have highly gratified rational curiosity, and, in conjunction with the animal races of its inhabitants, have afforded fresh proofs of Divine skill and wisdom.

Though the waters of the ocean are generally restrained within the same limits by the power of Him who "gave them a decree which they should not pass," yet they occasionally encroach in some places upon the shores, and in other places retire from them, so as in the one case to diminish, and in the other to enlarge the respective territories. It is, however, only on a small scale comparatively that these changes take place, and for the most part very gradually, though sometimes suddenly. Our own shores have thus been visited. In the reign of Henry I., the sea overflowed the estates of Earl Godwin, in Kent, and formed that celebrated bank called the Godwin Sands. On some shores it has made only temporary depredations, having retired again either of its own accord, or been driven back by the industry of man. It appears that about ten centuries ago the Isle of Ely was one of the most delightful spots in the kingdom, but the sea overwhelmed the lower parts of it, and destroyed for a time one of the most fertile valleys in the world. After some

centuries the waters gradually retired, or were drained off; and the country, though totally altered in its aspect, is resuming a degree of its former fertility. With the interior wonders of the deep we are but slightly acquainted: its wonders are for the most part performed in secret; and we have but little information from its abysses, except what we receive by inspection at very low depths, by the plummet in sounding, or from divers who descend from twenty to thirty fathoms.

In whatever point of view the ocean is contemplated, it is an object of surpassing interest. Nothing impresses more strongly upon the mind the ideas of sublimity, profundity, and vastness: the heavens themselves are inferior in this respect, as the impressions which they produce are less vivid, palpable, and effective. It may be true that by continued meditation on the concave sky and its brilliant orbs, we may amplify our conceptions more, and thus penetrate further into infinity; but their distances are so great as to weaken the immediate effect, and to require an effort of the imagination to realise the immensity of the scene; whereas a sight of the ocean in any of its various moods and aspects strikes us forcibly at once, and by a natural and easy process enables us to enlarge our conceptions to any assignable extent. The power of the Almighty is shown in its subjection to His will, and the ease with which He "stilleth the raging of the sea," and "taketh up the waters in the hollow of his hand."

## Exercise in Meanings and Derivation.—XIII.

*Divide and accentuate each word, and give its meaning and derivation.*

| | | |
|---|---|---|
| **whirling** | **evaporation** | **encroach** |
| **eddies** | **temperate** | **respective** |
| **rotation** | **centrifugal** | **comparatively** |
| **volume** | **modifications** | **depredations** |
| **testimony** | **obstacles** | **resuming** |
| **currents** | **opposite** | **abysses** |
| **reciprocating** | **concealed** | **sublimity** |
| **equilibrium** | **spiral** | **profundity** |
| **violent** | **innumerable** | **palpable** |
| **impulse** | **leviathan** | **effective** |
| **pendulum** | **rational** | **realise** |
| **inequality** | **restrained** | **assignable** |

## Notes.

1. CHARYBDIS.—A dangerous whirlpool near the coast of Sicily, opposite another called Scylla, on the Italian shore. This vortex frequently caused the destruction of the galleys of the ancients.

2. GODWIN SANDS.—Large sand-banks off the east coast of Kent, formerly solid ground belonging to Godwin, earl of Kent, the father of Harold, the last of the Saxon kings. It is said that the land was given to the monastery of St. Augustin in Canterbury, and that in consequence of the neglect to repair the sea wall by which it was enclosed, the water broke in and overwhelmed the whole tract. Many vessels have been lost on these sands, on which beacons have been placed to warn sailors of their danger.

3. LEVIATHAN.—A name applied in Holy Scripture to some monster of the deep, which many believe to be the whale. Job, in speaking of the ocean and all that is therein, says: "And there is that leviathan whom thou makest to take his pastime therein."

4. MAËLSTROM.—A well-known whirlpool, near the island of Moskoe, on the coast of Norway. It is very dangerous in winter, especially when the reflux of the tide is restrained by the north-west wind. The roar of the whirling waters at such times is so loud that it may be heard for miles, and small vessels and boats, and even whales, have been known to be sucked into the swirl and drawn under by the force of the current.

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# GLASS: ITS COMPOSITION AND USE.

## PART I.—INGREDIENTS AND MODE OF MANUFACTURE.

### GLOSSARY OF SCIENTIFIC TERMS, &c.

**sil'-i-ca** ......*the name given to pure flint, the most abundant solid constituent of the crust of the earth.* [Lat. SILEX, SILICIS, flint.]

**fu'-sing**........*melting by the agency of heat.* [Lat. FUNDO, I pour out or melt; participle, FUSUS, melted.]

**quartz**..........*rock crystal, a mineral composed chiefly of silica.* [Ger. QUARZ, the German name for this mineral.]

**la-bor'-a-to-ry**....*a workshop or place in which chemical operations are carried on.* [Lat. LABOR, toil, labour.]

**flu-or′-ic**........*belonging to a beautiful mineral called fluor, which is generally found in a crystallised state, when it is called fluor-spar.* [Lat. FLUO, I flow ; because fluidity must always precede crystallisation.]

**ni′-tre** .... *saltpetre or nitrate of potash.* [Gr. NITRON, soda, potash.]

**det-o-na′-tion**......*a loud and sudden report.* [Lat. DE, down ; TONO, I thunder.]

**cal′-cine**............*to reduce to powder by burning.* [Lat. CALX, limestone ; burning being necessary to reduce limestone or chalk to powder.]

**al′-ka-li**... ..*a salt soluble in water which has the property of neutralising acid.* [Arabic ALKALI, the ashes of the plant kali.]

**in-sol′-u-ble**.........*that which cannot be melted.* [Lat. IN, not ; SOLVO, I loose.]

**pul′-ver-ised**..... ..*reduced to powder.* [Lat. PULVIS, dust.]

**pre-cip′-i-tate**.....*a substance caused to fall to the bottom of a vessel in which it has previously been held in a state of solution.* [Lat. PRECEPS, headlong ]

**por′-ce-lain** ........*a fine thin and semi-transparent white ware.* [Ital. PORCELLANA, the shell of Venus, to which porcelain bears some resemblance in its semi-transparency.]

**lith′-arge** .. .....*vitrified lead separated from silver during the process of refining.* [Gr. LITHOS, a stone ; ARGUROS, silver.]

**man′-ga-nese**........*a whitish-gray metal difficult to fuse, and so called from its likeness to the magnet.* [Lat. MAGNES, a magnet.]

**bo′-rax**.....*a mineral salt used in soldering.* [Arabic BORAGA, to shine.]

Flint, which is called silica by chemists, is a most important ingredient in the manufacture of glass. It is a substance having in many points a close analogy to the earths, of which there are ten, namely, silica, alumina, zirconia, thorina, glucina, yttria, barytes, strontian, lime, and magnesia. They are all incombustible bodies, and were at one time thought to be incapable of decomposition ; but they are now believed to be certain substances, chiefly metallic, combined with oxygen. It was supposed by some chemists, from a comparatively early period, that the earths were compound substances, and many attempts were made to discover the supposed metallic bases. It was, however, left to Sir Humphry Davy to prove the truth of this supposition.

Davy was not able to produce a complete separation of silicium, the base of silica and oxygen, though the result of his experiment left no doubt in his own mind that this earth was composed of oxygen and a base. Berzelius, however, succeeded in effecting the decomposition, by fusing it with charcoal and iron. In this way he produced an alloy of silicium and iron. Pure silicium is an incombustible substance, and a non-conductor of electricity; it is not acted upon by any substance except fluoric acid, so far as we know at present. If dry carbonate of soda be added to silicium heated with nitre, a detonation is instantly produced.

Silica is a substance most abundantly distributed in nature; flint, sand, quartz, and gravel are all silicious, but not pure silica. They may, however, be reduced to an almost pure state by the following process: Take some small pieces of clear quartz, and calcine them at a low heat, and then reduce them to powder; mix the pulverised flint with three or four times its weight of carbonate of potassa, and fuse the compound—a process which will require great care, as the mixture will otherwise rise, and probably overflow the vessel. When the materials have been in perfect fusion for little more than half an hour, pour the compound of silica and alkali into an iron dish. It may afterwards be dissolved in water, and poured into diluted sulphuric or muriatic acid. A precipitate will be immediately produced, and as long as this continues a fresh quantity of the solution may be added. The sediment must then be washed and dried, which processes will put the experimentist into possession of a tolerably pure silica.

Let us now examine the use of this substance in the manufacture of glass. It is of great value in many works of art, such as the formation of earthenware and porcelain, but at present we must entirely confine our attention to the construction and use of glass.

When silica is mixed with an equal quantity of carbonate of potassa, and raised to a great heat in a furnace, it melts, and a glass is formed. It appears from history that the manufacture of glass was known at a comparatively early period. It was, however, an article of great value in the

time of Nero, who gave a considerable sum for two drinking glasses; yet it appears to have been sufficiently common for use in windows, as several of the houses in the town of Pompeii, which was buried by an eruption of Vesuvius, A.D. 79, were glazed with a thick semi-transparent glass.

Many other ingredients besides silica and an alkali are frequently used in the manufacture of glass. Flint glass is composed of silica, litharge, nitre, and manganese; crown glass of silica, soda, and lime; plate glass of silica, soda, lime, manganese, and oxide of cobalt; green bottle glass of silica, kelp, pearl-ash, and clay; artificial gems or pastes are made of pure silica, borax, nitre, and oxide of lead; other substances being added as required to produce the colour of which an imitation is to be formed.

In the manufacture of glass a great heat is required, for the alkali, which must be used, can only be melted at a high temperature, when it enters into composition with the earthy substance. It was once supposed that a very strong chemical attraction existed between the constituent substances, but this supposition has been disproved by many recent experiments. "Glass," says Dr. Faraday, "may be considered rather as a solution of different substances one in another, than as a strong chemical compound; and it owes its power of resisting chemical agents generally to its perfectly compact state, and the existence of an insoluble and unchangeable film of silica, or highly silicated matter upon its surface."

Glass is sometimes *cast* into the forms required, but is more frequently *blown*. If any of our readers should wish to have a practical acquaintance with chemistry, we would seek permission to give a little advice. Never depend on the skill and attention of others: be independent. If this recommendation be followed, it will save much money, much trouble, and, above all, much time: a man who wants workmen always in attendance at his laboratory table can never be a practical chemist. There are instances in which he will require assistance, but he must learn to do as much as possible for himself, otherwise he will never succeed in performing his experiments at the time or in

the manner he wishes. Now, of all operations required by the chemist, no one is more important than that of preparing his own glass vessels; and although the task may at first appear difficult, it will soon become easy by practice.

There was a time when all chemical experiments were made on so large a scale that it was impossible for any person to study the science without expending a great deal of money, and devoting all his time to the subject. But, in the present day, the student may manufacture nearly all his glass vessels with a common blow-pipe, which he may also construct. First, obtain or make a common pair of bellows, which may be worked with the foot. To the nozzle of the bellows attach a tube in a vertical position, and let it come through or by the side of the deal table on which the experiments are to be performed; to the end of this vertical tube a small jet must be attached, and fixed in such a manner that a current of air may be blown through it so as to direct the flame of a spirit lamp on any object, the temperature of which is to be raised. If this, however, cannot be obtained, a small blowpipe, similar to that used by goldsmiths, and supplied with air from the lungs, may be used. At first, the experimentist will not be able to obtain a steady flame by this means, but he will succeed after a little practice. Having obtained his blowpipe, the student must provide himself with some glass tubes, which are bought by the pound; the size of the tubes must be chosen according to the purposes for which they are required.

## Notes.

1. Acids.—A class of substances usually of a sour taste, which change certain vegetable blue colours to red, and restore blue colours which have been turned green, or red colours which have been turned blue by an alkali. United with earths, alkalies, and metallic oxides, they form important compounds called salts.

2. Alkalies.—Substances with an acrid taste, which melt in water, bubbling up when mixed with acids, and changing vegetable blues to green, yellows to brown, and certain reds to blue. The term, however, is usually

limited to potash, soda, and ammonia. Fixed alkalies are those which resist a red heat without evaporation.

3. Berzelius, Jons Jacob, an eminent Swedish chemist, renowned for his great skill in chemical analysis. He was born in 1779, and died in 1848. Out of respect to his memory the members of all the scientific societies of Sweden wore mourning for two months after his death.

4. Faraday, Michael, one of the greatest experimental chemists and natural philosophers that the United Kingdom ever produced. He was at first a bookbinder, but was assisted by Sir Humphry Davy to pursue his favourite study of chemistry, on which and the science of electricity he wrote some valuable works. He was for many years Lecturer on Chemistry and Electricity at the Royal Institution. He was born in London in 1794, and died in 1867.

5. Nero, Claudius Cæsar, the sixth Roman emperor, was born in the year 37, and reigned from 54 to 68. He persecuted the Christians, and is said to have been a monster of cruelty. He caused Rome to be set on fire in several places merely to gratify his wish to see a large conflagration.

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## Part II.—Experiments with Glass—Its Properties.

Being thus supplied with materials and instruments for manufacture, the student may commence his operations. Suppose, for instance, that he requires a test tube, upon which to make some experiments upon the affinity of substances. A piece of tube must be cut off to the length required, between three and four inches, and as both ends are open, one is to be closed. The flame of a spirit lamp is now directed upon the end which is to be sealed up, by the stream of air proceeding from the blowpipe. In a very short time the glass is raised to a high temperature, and becomes soft, and may be sealed up little by little, and when it appears to be quite closed heat it again until it is almost liquid, and then placing the opposite end to the mouth, blow into the tube, which will force the melted glass into a globular form, and make a very neat end. A thermometer bulb may be blown in the same manner. In performing this operation, it will be necessary to continue blowing into the tube, heating it again each time, until the

bulb is of the size required, and taking care not to inhale the heated air from the tube. It may be added here that extreme care should be taken in making all experiments with glass, chemicals, &c., lest injury should result.

When it is necessary to seal the ends of small tubes, it is better to take a piece longer than that required, and heat it at the point where it is to be sealed. The glass, when brought to nearly the point of fusion, may be suddenly drawn out, and a very fine capillary thread will be formed. At that part nearest to the end the thread may be broken, and will be at once closed by melting the glass at that point into a small globule, after which it may be acted upon as required, and perfectly formed. A lip may be made to this newly-formed vessel without any trouble; the glass will be heated in the same manner as before, and when quite soft is pressed into the form required by a piece of wire or the end of a file.

These hints may be of service to the young chemist, who will, after a little while, become expert in forming vessels of any shape he may require. The process is simple, and may be practised by any person; a little manual skill is all that is necessary. This description may also assist our readers generally in understanding the means by which glass is blown in factories, the only difference being that in large works the glass is melted in intensely hot fires instead of the flame of a spirit lamp.

Glass derives nearly all its importance from the possession of the property of transparency. It is true that if it were an opaque substance it would still be of great value, as it may be put into shapes which are required for ordinary domestic purposes. Still, its chief value depends on its capability of transmitting the rays of light. As this is its principal use, it will not be an inappropriate conclusion to this paper to illustrate its effects upon solar light.

Light moves in right lines when uninfluenced by any impeding medium; but when any transparent substance interferes its direction is turned—it is bent out of its course, or, in other words, is refracted. Before a ray of solar light can reach the earth, it must pass through the atmosphere, and, during its passage, it is refracted. Now,

the same ray may have to pass through a pane of glass, and in doing so is refracted again, because it enters a medium of different character; so that the ray of light, proceeding in a right line from the sun, is twice turned out of its course before it reaches the eye of the observer, situated in any apartment receiving light through glass. The effect of water in refracting or bending the rays of light can scarcely have been unobserved by any person who has been at all attentive to the phenomena surrounding him. If a stick be plunged into a stream of water it will appear as though broken at the surface, for immediately the ray enters the new medium it receives another direction. So light, passing from the atmosphere into glass, suffers the same change. Should, however, the ray be perpendicular to the surface, it will pass through without refraction.

As glass is one of the most transparent mediums with which we are acquainted, and may be easily converted into any shape required by grinding, it is commonly used in the construction of optical instruments. Some microscopes and telescopes are entirely formed of glass, that is, all but the exterior case; and the principle of their construction is readily understood by those who know the effect of differently formed lenses upon a ray of light. Glasses of some shape cause an object to appear larger than it is in fact, others make it smaller; some cause the rays to diverge, others converge them. The object of the optician, therefore, is so to place his lenses that they may effect the required object.

The principle of reflection is sometimes called into operation in the manufacture of optical instruments. The looking-glass is the most simple of all reflecting instruments; it consists of a piece of plate-glass, the surface of which is covered with a metallic substance, incapable of transmitting the rays of light. When a solar beam impinges on this medium, it is returned in a line which forms the same angle with a line perpendicular to the surface as the incident ray, but on the opposite side of the perpendicular. It is evident that a reflector may be made of any form by covering the anterior surface of glass with a

metallic compound, but such mirrors are far less used than those composed of metals. In the construction of optical instruments, metallic mirrors are almost exclusively used where reflection is required. The chief use of glass, therefore, in a scientific point of view, depends on its transparency, and its powers of refraction. If it were not transparent, it would be of no use to the chemist in his operations, for he could not observe the processes which are carried on; and it would be of no use to the astronomer or naturalist in the construction of telescopes and microscopes, if it did not possess the power of refraction. The common purposes to which glass is applied are so well known that it is altogether unnecessary to specify them.

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## Exercise in Meanings and Derivation.—XIV.

*Divide and accentuate each word, and give its meaning and derivation.*

| | | |
|---|---|---|
| affinity | direction | capability |
| globular | grinding | inappropriate |
| inhale | microscopes | solar |
| capillary | lenses | unfeeling |
| process | converge | interferes |
| manual | impinges | unobserved |
| intensely | anterior | plunged |
| properly | temperature | perpendicular |
| transparency | thermometer | optical |
| transmitting | fusion | telescopes |
| illustrate | globule | diverge |
| uninfluenced | practised | operation |
| medium | factories | incident |
| refracted | importance | scientific |
| attentive | opaque | |

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## AIR: ITS MECHANICAL PROPERTIES.

### Glossary of Scientific Terms, &c.

**a-er'-i-form**...*having the form or nature of air.* [Lat. AER, air; FORMA, form or shape.]

**dim-i-nu'-tion** ...*a lessening or making less.* [Lat. DIMINUO, I lessen.]

**ad'-ver-sa-ry** ......*opponent* [Lat. AD, to; VERTO, I turn.]

**pro-di'-gious-ly**..*enormously, to an astonishing degree.* [Lat. PRODIGIUM, a prodigy, something out of common.]

**e-las′-tic** ..*having a tendency to recover the original state or form after pressure or expansion.* [Gr. ELAUNO, I drive.]

**at′-oms**.....*the smallest pieces possible.* [Gr. A, negative; TEMNO, I cut; atoms being so small that they are not capable of further subdivision.]

**dif-fused′** ......*spread over or about.* [Lat. DI, apart or asunder; FUNDO, I pour.]

**dis-trib′-u-ted** .........*spread about, divided among several.* [Lat. DIS, apart or asunder; TRIBUO, I divide.]

**dis-tend′**...*to puff out, enlarge by pressure from within.* [Lat. DIS, apart or asunder; TENDO, I stretch.]

**as-cer-tained′**.....*determined, found out with accuracy.* [Lat. AD, to; CERTUS, sure, certain.]

**cu′-bic** .........*in the form of a cube, that is of a solid figure, whose length, breadth, and thickness are equal.* [Gr. KUBOS, a die.]

**de-com-po-si′-tion**...*destruction by decay, or the separation of a compound body into its original elements by decay or other causes.* [Lat. DE, from or apart; CON, together; PONO, I place.]

**fa-tigue′**...............*weariness or exhaustion from labour.* [Lat. FATIGO, I weary.]

**vari′-a-ble**.. ......*changeable, subject to change.* [Lat. VARIUS, different.]

**the′-o-ry**......*the exposition of the system of anything resulting from careful viewing or consideration.* [Gr. THEŌREO, I view.]

**mar′-i-time**.......*bordering on the sea, or pertaining to the sea.* [Lat. MARE, the sea.]

**hur′-ri-canes**...*violent storms during which the direction of the wind frequently changes.* [Span. HURACAN, a violent storm.]

**de-vas-ta′-tion** ...*destruction by laying waste the soil, &c.* [Lat. DE, from or down; VASTO, I lay waste.]

**trop′-ics**......*circles round the earth having corresponding circles in the sphere of the heavens, on reaching which the sun seems to turn in his course.* [Gr. TROPOS, a turning.]

**mon-soons′** .........*periodical winds in the Indian Ocean blowing from the north-east from October to April, and from the contrary direction during the rest of the year.* [Arabic MAUSIM, a time or season.]

We shall now examine the second class of fluids, distinguished by the name of aeriform, or elastic fluids, the principal of which is the air we breathe, which surrounds the earth, and is called the atmosphere. There is a great

variety of elastic fluids, but they differ only in their chemical, not in their mechanical properties; and it is the latter we are to examine. There is no attraction of cohesion between the particles of elastic fluids, so that the expansive power of heat has no adversary to contend with but gravity; any increase of temperature, therefore, expands elastic fluids prodigiously, and a diminution proportionally condenses them. The most essential point in which air differs from other fluids is by its spring or elasticity; that is to say, its power of increasing or diminishing in bulk, according as it is less or more compressed—a power of which liquids are almost wholly deprived.

The atmosphere is thought to extend to about the distance of forty-five miles from the earth; and its gravity is such, that a man of middling stature is computed to sustain the weight of about fourteen tons. Such a weight would crush him to atoms were it not that air is also contained within our bodies, the spring or elasticity of which counterbalances the weight of the external air, and renders us insensible of its pressure. Besides this, the equality of pressure on every part of the body enables us more easily to support it; when thus diffused we can bear even a much greater weight without any considerable inconvenience. In bathing we support the weight and pressure of water, in addition to that of the atmosphere; but this pressure being equally distributed over the body, we are scarcely sensible of it; whilst, if the shoulders, the head, or any particular part of the frame were loaded with the additional weight of a hundred pounds we should feel severe fatigue. On the other hand, if the air within a man met with no external pressure to restrain its elasticity, it would distend his body, and at length bursting the parts which would confine it, put a a period to his existence. The weight of the atmosphere, therefore, so far from being an evil, is essential to our existence. When a person is cupped, the swelling of the part under the cup is produced by taking away the pressure of the atmosphere; in consequence of which the internal air distends the part.

A column of air reaching to the top of the atmosphere,

and whose base is a square inch, weighs fifteen pounds when the air is heaviest. The rule that fluids press equally in all directions applies to elastic fluids as well as to liquids; therefore, every square inch of our bodies sustains a pressure of fifteen pounds, and the weight of the whole atmosphere may be computed by calculating the number of the square inches on the surface of the earth, and multiplying them by fifteen.

The weight of a small quantity of air may be ascertained by exhausting the air from a bottle, and weighing the bottle thus emptied. Suppose that a bottle, six cubic inches in dimension, weighs two ounces; if the air be then introduced and the bottle re-weighed, it will be found heavier by two grains, showing that six cubic inches of air (at a moderate temperature) weigh about two grains. In estimating the weight of air, the temperature must always be considered, because heat, by rarefying air, renders it lighter. The same principle, indeed, applies almost without exception to all bodies. In order to ascertain the specific gravity of air, the same bottle may be filled with water, and the weight of six cubic inches of water will be 1,515 grains; so that the weight of water to that of air is about eight hundred to one.

Thus, within the limits of from twenty-eight to thirty degrees on each side of the equator, the movements of the atmosphere are carried on with great regularity; but beyond these limits the winds are extremely variable and uncertain, and the observations made have not yet led to any satisfactory theory by which to explain them. It appears, however, that beyond the region of the trade winds, the most frequent movements of the atmosphere proceed from the south-west, in the north temperate zone.

This remark must be limited to winds blowing over the ocean, and in maritime countries; because those in the interior of continents are influenced by a variety of circumstances, among which the height and position of chains of mountains are not the least important. These south-west and north-west winds of the temperate zone are most likely occasioned in the following manner: In the torrid

zone there is a continual ascent of air, which, after rising, must spread itself to the north and south in an opposite direction to the trade winds below: these upper currents, becoming cooled above, at last descend, and mix themselves with the lower air; part of them may perhaps fall again into the trade winds, and the remainder, pursuing their course towards the poles, may occasion the north-west and south-west winds, of which we have been speaking. It has also been conjectured that these winds may frequently be caused by a decomposition of the atmosphere towards the poles, from part of the air being at times converted into water.

Hurricanes have been supposed to be of electric origin. A large vacuum is suddenly created in the atmosphere, into which the surrounding air rushes with immense rapidity, sometimes from opposite points of the compass, spreading the most frightful devastation along its track, rooting up trees, and levelling houses with the ground. They are seldom experienced beyond the tropics, or nearer the equator than the 9th or 10th parallels of latitude; and they rage with the greatest fury near the tropics, in the vicinity of land or islands, while far out in the open ocean they rarely occur. They are most common among the West India islands, near the east coast of Madagascar, in the islands of Mauritius and Bourbon, in the Bay of Bengal, at the changing of the monsoons, and on the coasts of China.

Whirlwinds sometimes arise from winds blowing among lofty and precipitous mountains, the form of which influences their direction, and occasions gusts to descend with a spiral or whirling motion. They are frequently, however, caused by two winds meeting each other at an angle, and then turning upon a centre. When two winds thus encounter one another, any cloud which happens to be between them is, of course, condensed and turned rapidly round; and all substances sufficiently light are carried up into the air by the whirling motion which ensues. The action of a whirlwind at sea occasions the curious phenomenon called a waterspout, which may be dispersed by firing in its direction from a cannon.

# THE LOCOMOTIVE POWERS OF ANIMALS.

## PART I.

### Glossary of Scientific Terms, &c.

**ter-res′-tri-al**.....*belonging to the earth.* [Lat. TERRESTRIS, of the earth, from TERRA, the earth.]

**sub-ma-rine′**.........*under the sea.* [Lat. SUB, under or below ; MARE, the sea.]

**po-ri′-fe-ra**..... *bodies having numerous pores or holes.* [Gr. POROS, a pore or hole ; PHERO, I bear.]

**lo-co-mo′-tion**......*the act of moving from place to place.* [Lat. LOCUS, a place ; MOTUS, motion.]

**ex-tra′-ne-ous**......*from without ; not belonging to or dependent on a body.* [Lat. EXTRA, without.]

**at-tri′-tion**..........*the act of rubbing against.* [Lat. AD, to or against : TERO, I rub.]

**im-ped′-i-ment**......*anything causing hindrance.* [Lat. IN, against ; PES, a foot.]

**ces-sa′-tion**......*stoppage, rest from moving.* [Lat. CESSO, I cease or give over.]

**coun-ter-act′-ing**...*operating against so as to hinder or destroy.* [Lat. CONTRA, against ; AGO, I do or act.]

**pro-gres′-sion**......*the act of moving forward.* [Lat. PRO, forward ; GREDIOR, I advance; participle, GRESSUS, advanced.]

**re-cruit′-ed**........*renewed, refreshed.* [Lat. RE, again ; CRESCO, I grow or increase.]

**con-trac′-tile**.......*capable of being shortened or drawn together at will.* [Lat. CON, together ; TRAHO, I draw ; participle, TRACTUS, drawn.]

**ap-pa-ra′-tus**.....*tools, machinery, or organs prepared to effect any particular purpose.* [Lat. AD, to ; PARO, I prepare ; participle, PARATUS, prepared.]

**ap′-te-ryx**.......*a bird which has no wings, or merely the rudiments of these organs.* [Gr. A, not ; PTERUX, a wing.]

**pon′-der-ous**...........*massive, heavy.* [Lat. PONDUS, a weight.]

**mam-ma′-li-a**........ .*animals which suckle their young.* [Lat. MAMMA, a breast.]

**con′-so-nance** .....*agreement, harmony.* [Lat. CON, together ; SONO, I sound.]

**mod′-i-fied**...........*contrived, constructed, adapted in form.* [Lat. MODUS, a measure ; FACIO, I make.]

**lac′-er-ate**......*to rend or tear.* [Lat. LACERO, I tear.]

**fo′-li-age**...*the leaves of trees and shrubs.* [Lat. FOLIUM, a leaf.]

**whole'-some** ........*tending to keep one hale or in health.* [Ang.-Sax. HAL, healthy; the hale or healthy man being whole or sound.]

**con'-gre-ga-ted** ......*gathered or assembled together.* [Lat. CON, together; GREX, a flock or herd.]

**in-a-bil'-i-ty**........ ...*want of power.* [Lat. IN, not; HABILIS, able, having power to do anything, from HABEO, I have.]

**ce'-ler-i-ty**...... .....*swiftness, rapidity of motion from place to place.* [Lat. CELER, swift.]

Some animals are ordained to a purely terrestrial existence: they are bound to the solid surface of the earth, or at the utmost only elevate themselves above its level as far as the trees of the forest will enable them. Others traverse the boundless regions of the air; they leave the ground or the water at pleasure, and soar above the mountains of the former and the billows of the latter. Others are purely aquatic: they cleave the blue waters of the ocean; they pursue their food in its ever-moving expanse, and are at home in its depths. Others, again, are submarine, or subaquatic: they live in the water, but their station is at the bottom, on its sandy or rocky bed, from which they cannot rise. And some, having fixed themselves to one local spot, there become stationary like the plant, there grow, reproduce their offspring, and die. Such is the case with the sponges *(porifera)*, the lowest link in the chain of animal organisation. Looking, however, at the animal kingdom as a whole, we see it characterised by powers of locomotion, centered, not in extraneous causes, but in the organic structure of the fabric of every individual being. Inorganic bodies are absolutely inert; if not moved by extraneous force they remain at rest for ever; and when moved would move for ever, were it not for the checks they experience from attrition with other bodies, from the impediment caused by the medium through which they are projected, and from the attraction of gravitation. Take these causes away, and a cannon-ball, shot from a piece of ordnance, would move on for ever.

In the animal kingdom the case is different; there, motion and cessation from motion depend upon the agency of internal and organic forces; and as the animal, in com-

mon with all *matter*, experiences the agency of those causes which arrest the motion of inert bodies, its force is necessarily employed in counteracting that agency. This, however, is not done without an expenditure of the energies of the system, which require to be recruited perpetually by food and rest. The immediate agents in the locomotion of all animals are masses of contractile fibres, termed muscles, which act under the influence of the will upon the levers by which the individual makes its way on the earth, in the air, or in the water. These levers, with their muscles, constitute what we mean by the limbs. In a vast range, however, of animal beings, no definite limbs exist, and yet they move, and move rapidly. In this case the body itself acts the part of limbs, either throughout the whole or a considerable portion of its surface, and the muscular forces are arranged accordingly. In the snake, the long body performs the part of a succession of levers, which, by the united action of a series of muscles, concur in effecting progression.

As the movements of animals are immediately connected with the nature of their food, and the appointed methods for obtaining it, we may expect to find a great diversity, not only as respects manners, but powers; not only as respects the way by which progressive motion is effected, and the character of the apparatus for effecting it, but also as respects the freedom and the extent to which the enjoyment of locomotion is carried. Between the sponge, which tufts the walls of the sea-cave, and the shark, which cleaves the foaming billows, the powers and extent of locomotion which myriads of living beings exhibit are multitudinous in their degrees. Nor is there less diversity if we confine our survey to the land. The falcon, on wide-spread wings, travels sixty miles an hour; the pheasant can scarcely fly across a park, or from one wood to another; the apteryx of New Zealand, and the oceanic penguin, cannot fly at all. The antelope bounds over the plain, on limbs fleet as the wind; the great anteater slowly drags itself along. The monkey climbs the trees, and leaps from branch to branch; the ponderous elephant moves along in state beneath their shade. The seal can neither climb the tree nor stalk over

the verdant turf; it shuffles along on the shore with awkward rapidity, but having attained the water, it swims with ease and grace.

Confining our attention for the present to the mammalia, let us see what are the modes of progression allotted to this class, and what are the organs by which locomotion is effected. The greater number of mammalia have four limbs, in pairs; on these the trunk is supported, and by means of these locomotion is effected. One exception here occurs, and one only—we allude to man. His limbs are indeed four, but only two are used as organs of locomotion, the arms being free; in other four-limbed mammalia the case is different. All mammalia, however, have not four limbs; in the whale tribe there are but two, and these are paddles or balances, and assist in rowing the boat-like body through the water.

With few exceptions, all mammalia possessing four extremities or limbs are capable of free and active progression on the ground; yet is there great variety in the character of their movements. Some have a light and easy step, and bound gracefully over the plain; some move with a slow and heavy pace; and some seem as it were to drag themselves from place to place with labour and fatigue. In every instance, however, the locomotive powers of the animal are in consonance with its necessities and the nature of its food. The obtaining of food is the first point bearing upon the external organisation of every creature; and as the character of the internal machine is adapted to the nature of the food, so is there given every external qualification for obtaining it, whatever it may be. Take a lion or a tiger, for example. These are animals destined to live upon the flesh of others which they destroy, and their teeth and the whole of their digestive apparatus are modified accordingly. But, with this appetite, what would they do were their powers of progressive motion those of the ox? They must steal silently upon their prey, or spring upon it from their ambush; their limbs must not only be vigorous to support their body, not only armed with talons to lacerate, but free and active. The heavy, clumsy movements of the ox would betray them at once;

but see how lightly they bound along, how silently they approach their victim, how easily and suddenly they make their fatal spring. Contrast the movements of such animals with those of the heavy buffalo or rhinoceros. These ponderous beasts may indeed put forth their pace into a clumsy and perhaps rapid sort of gallop ; but the earth shakes beneath their feet : and what of that ? They have not to surprise their prey in order to gorge upon flesh ; the rank grass and foliage of the marsh, which the lion cannot eat, affords them a wholesome repast. Look again at the fleet-limbed deer or antelope ; to them is the herbage of the plain allotted for food, and when it fails in one district they have to seek another. They scour the wilderness to-day ; they browse here in congregated herds—which often in a few hours convert a verdant spot into a barren desert ; and to-morrow they are far away ; they are ever in motion. Give the antelope of the plains, or the chamois of the rocks, the limbs of the anteater, and they would perish with hunger, to say nothing of their inability to escape the slowest of their many enemies. Turn to the anteater: his limbs have prodigious force, but his pace is slow and dragging ; awkwardly, as it appears, he crawls on his knuckles in search of the clay-built houses of the termite ant, and these he has to demolish before he can obtain his food. These houses are multitudinous ; he needs no celerity of locomotion in order that he may traverse in due time a vast extent of country before his food can be discovered ; nor need he steal silently upon it, in the manner of the tiger ; at all times it is within his reach, but how is he to obtain it ? Applying his great hook-like claws to the compacted mound of clay, he tears it open, by an exertion of enormous strength ; his arms, indeed, are levers, adapted to his wants and habits.

We might here go on to show how varied in its details is the locomotion peculiar to the different races of mammalia which tenant the ground, and how, in every case, it accords with the general nature and necessities of the species ; but the task would be long and tedious. We may observe, however, that in all they are admirably adapted to the end in view.

## Notes.

MAMMALIA.—All things in nature have been broadly classified into *three* kingdoms: 1. The ANIMAL KINGDOM, including everything that partakes of the nature of an animal or living being, or is possessed of a living organisation, however simple; 2. The VEGETABLE KINGDOM, including all forms of plant life; and 3. The MINERAL KINGDOM, including all inorganic structures, such as stones, coal, &c.

The animal kingdom is subdivided into FIVE sub-kingdoms:—1. VERTEBRATA, or animals possessing a spine or backbone, from the Latin *vertebra*, a joint of the backbone; 2. ANNULOSA, or animals whose bodies are formed in sections or segments, as a fly, beetle, crab, and worm, from the Latin *annulus*, a ring; 3. MOLLUSCA, or animals having a soft body, such as the squid, snail, slug, and oyster, from the Latin MOLLIS, soft; 4. CŒLENTERATA, or animals having a hollow sack-like interior or intestine, into which their food is conveyed, as the sea anemone, from the Greek *koilos* hollow; and *enteron*, an intestine; and 5. PROTOZOA, or animals of the lowest grade in which the organs are merely rudimentary, as the sponge; from the Greek PROTOS, first; and ZOÖN, an animal.

Returning to the vertebrata, or animals possessing a backbone, we find that this sub-kingdom is divided into *five* classes: 1. MAMMALIA, or animals which suckle their young, from the Latin *mamma*, a breast; 2. AVES, or animals furnished with wings, from the Latin *avis*, a bird; 3. REPTILIA, or animals which creep or crawl on the ground, as the tortoise, crocodile, lizard, and snake, from the Latin *repo*, I creep or crawl; 4. AMPHIBIA, or animals that can live on land or water, as the frog and blind worm, from the Greek *amphi*, both; and *bios*, life; and 5. PISCES, or fish, from the Latin *piscis*, a fish.

The remaining sub-kingdoms are also divided into classes, which it is not necessary to mention here; it will be sufficient to say that each is distinguished by some peculiarity of structure, separating it from the others to which it is allied by the broad marks of analogy by which the classes are grouped into the sub-kingdom.

The classes, in their turn, are divided into orders, and these again are sub-divided into families, while the family comprehends many species. Thus mammalia are separated into many orders, of which it will be sufficient here to point out the order BIMANA, or two-

handed animals, which includes the human race alone ; QUADRUMANA, or four-handed animals, which includes the monkeys ; and CARNIVORA, or flesh-eating animals, which includes the lion, tiger, and all beasts of prey. Domestic animals are mostly included in the order ARTIODACTYLA, which comprehends non-ruminant animals, which do not chew the cud, as the pig and the hippopotamus ; and ruminant animals, as the cow, sheep, stag, and camel. The horse belongs to another order, PERISSODACTYLA. The main point of difference in these animals lies in the hoof, the hoof of the horse being solid, while those of the pig, cow, sheep, &c., are divided.

The preceding remarks, although brief and insufficient, as space prevents the insertion of a complete summary of the various orders throughout the classes of the animal kingdom, are, nevertheless, sufficient to indicate how the classification of animals has been effected by naturalists.

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## THE LOCOMOTIVE POWERS OF ANIMALS.

### PART II.

We said that most four-limbed mammalia are capable of free and active progression on the ground, with a few exceptions. Of these exceptions, we may first allude to arboreal mammalia—that is, to such as live more or less commonly among the trees. Many animals are equally as terrestrial as arboreal ; they are as nimble and active on the ground as among the trees. This is the case with the squirrel and others. It will, to a certain degree, even apply to the monkey tribes, and to the quadrumana generally ; though here we see an organisation expressly fitting them for arboreal habits. On the ground, however, the motions of the quadrumana are not graceful nor easy ; indeed the orang-outang can scarcely manage to get along ; nor are the spider monkeys in a much better condition. Many, however, of the monkeys, and others of the quadrumana, scamper along on the level ground, if not gracefully, at least with considerable celerity. It is, however, among the branches of the trees that they exhibit those surprising feats of agility, those rapid evolutions, which

render them attractive and interesting. They have four hands, and grasp alike with all: hence their great security. There is one arboreal animal, an animal indeed expressly so, which can hardly be said to have the power of locomotion on the level ground at all, but which is quite at its ease among the trees of the forest. Yet are its manners and its organisation widely different from what is displayed by the quadrumana. We allude to the sloth. His four limbs terminate in hooks, not in hands, and he lives suspended by these, on the under surface of the branches of the forest, which he traverses as a fly does the ceiling of a room (save that the apparatus of the fly is of a very different nature). Had the sloth hands, they would become weary, and fail; for the under side of the branch is his perpetual abiding place: nothing but hooks would serve him—hooks drawn down by an elastic ligament, so as to be always firmly pressed against the branch. These, then, are the convenient instruments allotted him by the great Creator.

There is another arboreal animal to which we may allude, and which, though arboreal and quadrumanous, has nothing of the celerity of the monkey in its movements among the trees; it is the loris. The actions of this singular creature, which is nocturnal in its habits, are slow, cautious, and noiseless; it attains, by an almost imperceptible progress, the same object which another animal would attain by extreme rapidity; it steals upon its prey (birds and insects) with a motion almost as slow, almost as sure, and quite as noiseless, as the minute-hand of the clock advances to a given point on the face of the dial.

Many mammalia are partially aquatic in their habits; some entirely and exclusively so. Where an animal's habits are partially aquatic, we find the limbs to be short, the feet broad, or webbed, and the progressive movements on the land slow, and more or less awkward. This is the more palpable, the more aquatic the habits are. The otter, for example, is aquatic; it swims and dives in pursuit of its prey with great ease and rapidity; its limbs are short, its toes webbed, its body long, its head compressed, its tail

strong and tapering, its fur fine and close. On the land it cannot run quickly, nor for any length of time, but when attacked, or driven from its hole, at once makes for the water. Yet is it by no means so continually in the water as the seal, which, though it breeds in caverns on the shore, and reposes on the rocky islets scattered over the seas to which it is partial, is yet almost constantly in the water; and accordingly we find its limbs still less adapted for land than those of the otter, and the whole of its organisation in accordance. Its limbs are short and strong, the hinder pair being thrown back as far as possible, and developed into paddles. It can swim in every position; it can dive, and play amidst the curling waves. Here its actions are unconstrained and graceful; but on the shore it drags itself along with awkwardness, and shuffles for safety into the welcome sea.

If, from the seal, we turn to such mammalia as are absolutely and entirely aquatic—mammalia which cannot exist on the land, though they breathe the air—which bring forth their young, and sport and repose amidst the waste of waters, we shall see in them the organs of progression adapted for such an element in the most complete state, with the exclusion, however, of the slightest possibility of their being used on land. Such mammalia are the whale, the grampus, the porpoise, the dolphin, the dugong, and others. Here we find the limbs reduced to the anterior pair, which are truly paddles, and nothing else; the body, destitute of fur or hair, is covered with a smooth, glossy skin, enveloping a layer of blubber intervening between it and the muscles; and the figure that of a fish, except that the tail spreads out horizontally. This is indeed the chief organ of progression: with this the animal strikes the water, and propels its huge body through the foaming ocean, or dives into the gulf, or reascends to the surface for air. Thus framed and fashioned for their ocean home, what could these monsters of the deep do on the land? They would of all creatures be most helpless, and their mighty strength would not avail to save them from destruction by the most puny foe.

But some mammalia are aerial; they wing their way

through the sky: such are the bats. A parachute is given to many animals, as, for instance, to the flying lemur, the flying squirrel, the flying opossum—all arboreal animals—by means of which they are enabled to launch themselves to considerable distances; and they find in this, we doubt not, a great advantage; still they are not quite correctly termed flying animals, for they cannot, and do not fly. With the bats the case is very different. On a level surface the bat is as awkward as the seal: its limbs are not adapted for terrestrial progression; it drags itself along by catching with its hooks the inequalities of the surface upon which it is placed; but the fact is, that its limbs are the mere supporters of an extensive membrane which acts the part of wings, and with which it mounts into the air, and there gives chase to its insect food.

### Exercise in Meanings and Derivation.—XV.

*Divide and accentuate each word, and give its derivation and meaning.*

| | | |
|---|---|---|
| **arboreal** | **aquatic** | **parachute** |
| **agility** | **scattered** | **membrane** |
| **perpetual** | **destitute** | **surprising** |
| **rapidity** | **aerial** | **apparatus** |
| **attacked** | **extensive** | **imperceptible** |
| **anterior** | **quadrumana** | **compressed** |
| **fashioned** | **terminate** | **absolutely** |
| **supporters** | **nocturnal** | **horizontally** |
| **nimble** | **partially** | **inequalities** |
| **evolutions** | **unconstrained** | **correctly** |
| **ligament** | **intervening** | **progression** |

## THE LOCOMOTIVE POWERS OF ANIMALS.

### PART III.

Passing from mammalia to birds, we at once observe that most are furnished with organs of progression for the ground and the air, and that some, in addition, are also endowed with the powers of swimming and diving. We need not say that the wings are their organs of aerial progression. But in some birds these wings are so modified

as to be incapable of elevating their possessor into the regions of the atmosphere. Of these exceptions to a general rule we may allude first to the ostrich, emeu, cassowary, &c. Their powers are concentrated in the limbs, or organs of terrestrial locomotion, and not in those of flight, as is the case in most birds. They scour the plain with astonishing rapidity, and emulate on the ground the velocity of the eagle in the air. But there are other birds incapable of flight, and also incapable of free terrestrial locomotion : we allude to the great auk and the penguin. These strange birds occupy, among their class, the situation which the seals take among the mammalia : they are essentially aquatic. Now we may observe, that in all birds that run or walk on the ground, or hop with graceful ease from spray to spray, the body must be fairly balanced upon the limbs ; it must require but little exertion on the part of the bird to maintain itself in its natural attitude : hence we see the limbs placed but little beyond the centre of the body, as may be noticed in the common fowl. But when we turn to aquatic birds the case is different : here we find the limbs placed further backwards ; and the more so, the more decidedly aquatic the species may be. They are also short, stout, and have the toes webbed or lobated. This may be seen in the duck, and much more so in the grebe, or diver. But when we turn to the great auk or the penguin, the posterior situation of the limbs is complete : hence on the land these birds are as awkward as the seal, and shuffle along much in the same manner ; fly they cannot, for their wings are converted into paddles, with which (for they swim with the body quite immersed), they plough their way through the sea with wonderful velocity. Here they pass the whole of their existence, except when brooding over their eggs, or taking repose on the desolate shores that border their favourite element.

Reptiles and amphibia have four limbs, or only two limbs, or none ; they are terrestrial and aquatic. The motions of most, upon land, are crawling ; yet, as we see in the little *lacerta agilis* (nimble lizard), they often run along very nimbly ; others, however, as the tortoises, proceed with a slow, uneasy pace. The snake has no limbs, yet it

is very rapid. The fact is, that we may regard the whole body of the snake as one long apparatus for locomotion, which effects the object by a series of curves, each pair of ribs becoming in succession a sort of fulcrum. The snake also swims most gracefully, wreathing its body in the same series of curves. The frog proceeds by leaps on the land, its long and muscular hind legs throwing the body forward to a considerable distance. It uses the same action in the water, where the effect produced is to propel the body along, each stroke adding to the impetus. The crocodile swims by striking laterally with his broad and powerful tail—"he maketh the deep to be hoary;" and the iguana, which occasionally takes to the water, lashes his long, slender tail from side to side with great rapidity.

Of fishes little need be said: their tail is their principal organ of aquatic progression, and its action is lateral; the fins are rather balancers and directors than the immediate organs of their progression.

Of the inferior tribes of living beings, the progressive motion is performed by various agents. Some, as crabs, crawl along the bottom of the sea, or trip along the beach when the tide is out, using their long limbs, cased in solid armour, with great dexterity. Others, as shrimps, lobsters, &c., swim on their side, flapping the water with their expanded tail; and they creep also by means of limbs placed beneath the thorax or chest.

In the myriapoda, of which the centipede is an example, we see a series of limbs on each side of the body, consisting of a number of segments, each segment having its own pair. The progressive motion of these reptile insects is serpentiform, and often rapid. The mechanism of the limbs of the pulex (flea) enables the creature to take enormous leaps; and many other insects, as the grasshopper, &c., do the same. Most insects are furnished with wings, by means of which they are enabled to fly with the greatest ease and velocity; witness the *libellula* (dragon-fly), whose flight is astonishingly rapid, and whose aerial evolutions resemble those of the humming bird. But insects are furnished with legs as well as wings, and can walk and run with facility; some indeed have their feet furnished

with suckers, so that they can traverse the ceiling of a room, or ascend a pane of glass, with the utmost facility. We see this exemplified in the common fly. Some insects are aquatic: they swim and dive, seldom quitting the water for any length of time: the dytiscus is an instance. In this water beetle the hind limbs, which are situated far behind the two anterior pairs (for insects have six limbs), are fashioned like oars, and are moved by powerful muscles; and the whole structure of the body is adapted for an aquatic medium. The asterias (or sea-star) creeps along slowly by means of rows of fibrils or *tentacula*, which are protruded through small orifices on the under surface of each ray, and which are capable of being withdrawn. Each of these feet terminates in a sort of sucker; their number is prodigious. Reaumur counted 304 in each of the five rays of the starfish, or 1,520 in all.

The *echinus* (or sea-urchin) employs its spines as levers: they are united to the crust of the animal by a ball and socket articulation, and are freely movable in every direction. The animal, thus furnished, moves along on the bottom of the sea at a tolerably quick rate. It is also aided by slender tentacula, tipped with suckers, protruded from numerous small orifices, as we have noticed in the sea-star.

The animals (*gasteropoda*) inhabiting univalve shells, as the common garden snail, advance by an undulatory motion of the under surface of the body, as anyone may see who watches a snail crawl up a pane of glass. This *body*, as it is commonly termed, is, in fact, the *foot* of the animal, and is composed of an interlacement of bands of muscular fibres, the working of which, on looking at the opposite side of the glass, will be plainly seen. This foot, lubricated with a slimy secretion, acts also as a sucker.

Independent progressive motion does not appear to be possessed by all the animals (*conchifera*) inhabiting bivalve shells. Many, however, as the mussel, possess a muscular foot, which they protrude, in order to effect a crawling motion, raising themselves at the same time on their inner (or ventral) edge. We have often watched the great fresh-water mussel thus proceeding: having opened the shell a

little, it protrudes the foot, raises its shell upright, and advances by a succession of jerks, leaving a furrow in the soft mud over which it traverses. These furrows, as we have seen, are many yards in length, and bear testimony to the perseverance of the slow-moving creature by whose shell they were ploughed up.

Many aquatic animals of the lower grades of existence move and swim by means of vibratile *cilia* or fibrils, which, ever in rapid motion, keep up a perpetual eddy in the fluid around them: such is the case with many species of animalcules. To some, as the beroe, curious membranes are also added, for striking the water, as a bird strikes the air with its wings; and to others again (as the beautiful physalia, or Portuguese man-of-war) are given an air-bladder, for the purpose of enabling the creature to float, and a delicate membranous sail, to catch the breeze before which it sails along. It is a most interesting sight to witness a fleet of these zoophytes, with their purple sails all set, quietly moving over the calm seas of the inter-tropics, fanned onwards in their course by the gentle air, which does not even ruffle the surface of the water. Should the wind rise and the water roughen, they take in their sails, and, in a manner not understood, discharge or absorb the air which distended their vesicles, and sink for safety into the depths below.

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## Exercise in Meanings and Derivation.—XVI.

*Divide and accentuate each word, and give its derivation and meaning.*

| | | |
|---|---|---|
| elevating | fulcrum | undulatory |
| exertion | expanded | protrude |
| immersed | serpentiform | zoophytes |
| amphibia | articulation | balanced |
| dexterity | secretion | paddles |
| segments | membranous | reptiles |
| tentacula | emulate | laterally |
| lubricated | lobated | centipede |
| vibratile | desolate | fibrils |
| concentrated | impetus | interlacement |
| attitude | thorax | grades |
| posterior | traverse | intertropics |

## Notes.

1. ANIMALCULES. — Animals which are so small that they cannot be studied without the aid of a microscope, are generally spoken of as animalcules. The term is derived from the Latin *animalculum*, a little animal.

2. CONCHIFERA. — A name given to the animals tenanting certain bivalve shells, which are susceptible of no impression except that of immediate contact. The name is derived from the Latin *concha*, a shell; and *fero*, I bear.

3. GASTEROPODA. — A term applied to many molluscs, such as the snail, slug, whelk, periwinkle, limpet, whose motion proceeds from the contraction and extension of the lower part of the body, their belly serving, as it were, as a foot on which they move. The name comes from the Greek *gaster*, the belly, and *pous*, a foot.

4. MYRIAPODA.—The animals which belong to the second class of the sub-kingdom Annulosa, and which are ranked collectively under this name, the first class comprising "Insecta." The term comes from the Greek *myrias*, ten thousand, and *pous*, a foot. In its scientific sense it merely means "many-footed."

5. UNIVALVE and BIVALVE.—A univalve is an animal whose exterior covering, or shell, consists only of one piece, while in a bivalve it consists of two pieces. These words are derived from the Latin *valva*, a leaf of a folding door, or valve, and *unus* one, and *bis*, twice. Snails, limpets, whelks, periwinkles, and cowries are univalves, while oysters and scallops are bivalves.

6. VESICLES.—Small bladder-like cells or cavities in any animal body, from *vesicula*, a little cell; from *vesica*, a bladder.

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## THE CHALK AND COAL DISTRICTS.

### GLOSSARY OF SCIENTIFIC TERMS, &c.

**de′-bris** ........*rubbish, broken pieces of anything.* [Fr. BRISER, to break.]

**su-per-in-cum′-bent** ....*lying above or on the top of anything.* [Lat. SUPER, above; IN, on or upon; CUMBO, I lie.]

**in-den-ta′-tions**...*deep marks made as it were by biting.* [Lat. IN, into; DENS, a tooth.]

**fur′-rows** .. ...*long grooves or trenches made by a plough, or other means.* [Ang.-Sax. FUR, a trench.]

**skel′-e-tons**....*bony structures of animals on which the flesh, muscles, &c., are supported.* [Gr. SKELETOS, dried.]

**ir-rup′-tion**.. ...*a breaking in upon.* [Lat. IN, on or over; RUMPO, I break; participle, RUPTUS, broken.]

**des′-ti-tute**.........*in want of, devoid of.* [Lat. DE, from or away; STATUO, I place.]

**dykes**.........*wall-like masses of igneous rocks in the fissures of stratified rocks.* [Ang.-Sax. DIC, a mound or bank.]

**dis-lo-ca′-tions** .........*parts thrown out of their proper places, displacements.* [Lat. DIS, away or apart; LOCO, I place.]

**ar-rest′**.........*stop, stay.* [Fr. ARRÊTER, to stop.]

**nod′-u-lar** ...........*having the appearance of little round balls or lumps.* [Lat. NODUS, a knot.]

**chal-ced′-o-ny** ...*a variety of quartz having the pale blue tint of milk and water.* [Derived from CHALCEDON, in Asia Minor.]

**shale** ......*a rock or deposit of slaty structure.* [Ger. SCHALE, a shell or husk.]

**ram-i-fi-ca′-tions** ...*divisions separating and proceeding in different directions like the boughs of a tree.* [Lat. RAMUS, a bough; FACIO, I make.]

**bi-tu′-men**...*a name given to a dark inflammable substance, such as natural pitch or asphalt.* [Lat. BITUMEN, pitch.]

**ar-gil-la-ceous′**.... · ...*clayey, formed of clay.* [Lat. ARGILLA, white clay.]

**sul′-phu-ret** ...*a combination of sulphur with an alkali, earth, or metal.* [Lat. SULFUR, brimstone.]

**in-ex-haus′-ti-ble** .........*that which cannot be used up.* [Lat. IN, not; EX, from; HAURIO, I draw; participle, HAUSTUS, drawn.]

**ves′-ti-ges**.........*marks, signs.* [Lat. VESTIGIUM, a foot print or track.]

**pri-me′-val**.....*belonging to the earliest times.* [Lat. PRIMUS, first; ÆVUM, an age.]

The stratum which comprises the chalk formations is remarkable for its extent, and for the pebbly debris spread over its service. At the boundary line of the chalk with the superincumbent layers, a partial destruction after its formation seems to indicate an interval of time, and at its union with the sand and gravel of the plastic clay there are deep indentations on its surface, and furrows which bespeak the action of agitated water. The English pebble beds and solid flints show that the chalk was consolidated before the wearing away of the upper strata; besides that, the two strata exhibit different organic remains.

In the vale of Shipstone in Warwickshire, and in the northern part of the county of Northampton, near Rutlandshire and Leicestershire, the quantity of chalk-flints mixed with rounded fragments of hard chalk suggest the idea that this formation once covered these districts fifty miles beyond the present nearest line. The transition to the more recent deposits seems to have been sudden.

The chalk which runs across the eastern and southern counties of England from Yorkshire to Dorsetshire is only the western boundary of a most extensive tract, which fills the interior area of the central basin of Europe. At Flamborough Head the mountain mass is scooped into magnificent arches, forming vast porticoes to its caverns, on the northern side. Between Beechy Head and Brighton the coast section exhibits a fine range of chalky cliffs. At Purbeck the chalk, which usually lies horizontally, assumes a position nearly vertical, exhibiting at Headfast Point the most singular phenomena in stratification.

Through the northern coasts of France, the chalk line corresponds with that of the southern shores of England. From Calais towards Wisant, a range of chalky cliffs faces those of Dover, exhibiting similar interior subdivisions: 1. Chalk with flints on the top of the cliffs; 2. Chalk with few flints; 3. A bed with organic remains; 4. Chalk without flints; and 5. Gray Chalk. The strata rise under a low angle westward, and near St. Pol, as at Folkestone, are succeeded by the substrata of blue marl and green sand. Near Cape de Caux are some singular pyramids of chalk resembling the Needles of the Isle of Wight, and called also Les Aiguilles—the Needles. The correspondence between the cliffs on each side the straits of Dover leads to the conclusion that they have been separated by an irruption of the sea. Hence the strata in the vicinity of Calais once formed part of the tract now termed the chalk basin of London.

The *chalk basin of Paris* has been an object of great curiosity to geologists since the admirable discoveries of Cuvier. The materials composing it seem to have been deposited in a vast concavity or gulf, lined with chalk. It contains extraordinary relics of organised beings: myriads

of marine shells in regular alternation with fresh water shells, skeletons of animals unknown to the living world, and bones scattered over the more superficial strata, belonging to considerable species found at present only in very distant countries.

Partial chalk tracts occur beyond the European area. A remarkable deposit forms the basis of the great basaltic area, in the north-east angle of Ireland, containing flints, and resting on green sand. Both North and South America appear to be destitute of chalk.

The most curious feature of this formation is the beds of nodular flints alternately distributed through the mass. They are absent in the lower, but uniformly present in the upper parts of the chalk formation. When first taken from their native bed, flints present an appearance of moisture in their fractures, having probably been produced by the filtering of silicious water through the particles of silica deposited originally among the chalk. Chalcedonies may often now be seen forming by the trickling of water through silicious substances. A sponge is peculiarly favourable to the formation of chalcedony in chalk. Traces of these zoophytes may generally be observed, and beautiful figures are sometimes produced by their ramifications radiating through the chalcedony. The only mineral common to all chalks is iron pyrites, which varies in size from a pea to an orange. Occasionally immense blocks of carbonate of lime are found.

Coal consists of carbon in the proportion of sixty, and bitumen in that of forty parts. The newest formation is considered to be that of alluvial soils, where the strata are not parallel. The next in age is the newest trap, the result, as it is supposed, of deluges. The coal of this class is generally covered with clay or basalt, and contains no vegetable impressions or remains.

The independent coal formation is considered to be the oldest, as the beds are unconnected. The strata are remarkably parallel, and overspread with indurated clay or shale. It contains numberless impressions of vegetables, and sometimes of fresh water shell-fish. Of this kind are the great coal deposits of England.

Between the strata of coal occur one or two of sandstone, clay, bituminous shale or rubblestone, argillaceous ironstone, or limestone.

It is observable in every country, that though the shale above the coal contains impressions of vegetables or fish; the strata of the subjacent substances are destitute of them. Although the strata are generally parallel, yet they are frequently interrupted in other directions by slips, sinkings, &c., called *troubles*, resembling cracks or fissures, filled with sand, gravel, and other deposits. Sometimes they are divided by vertical veins of basalt called *dykes*, which separate the strata without altering their direction. Close to the dykes the coal appears as if it had been pulverised, and even decomposed.

The dislocations of the coal strata are also termed *faults*, which are generally advantageous, though they partially interrupt the miner's operations; for fractured strata are often bounded by faults which arrest and prevent an overflow of water.

Coal occasionally contains metallic substances, as native silver, sulphuret of lead or of mercury, and antimony; pyrites, however, or the sulphuret of iron, is the most common.

The vegetable remains, particularly the stems of plants in coal measures, are frequently of great size. In the quarry of Craigleith one of forty-seven feet in length was discovered, having its bark converted into coal. Many of the plants indicate a climate of excessive heat, and it is said that the vegetation is not continental but insular.

Buffon states that there are no fewer than 400 collieries in France; that at Namur is the deepest in the world, being 2,400 feet. Our coal, however, is unquestionably superior in quality to all other, and occurs in greater quantities. The coal mines in South Wales alone would supply the present demand for hundreds of years to come. The collieries in Flintshire, Glamorganshire, Colebrook Dale, Shropshire, and at Kingswood, are in the vicinity of secondary limestone, while the deposits at Newcastle and Whitehaven are in secondary sandstone. The two latter, the one on the north-east, the other on the north-west

coast, are supposed to form one deposit of numerous strata, extending across the island and beneath the sea. At Whitehaven the workings stretch a mile along, and 600 feet below the ocean. One of the collieries at Newcastle is 810 feet deep, and passes through seventy-three strata. The profitable stratum generally lies beneath all the others, and is called the main coal. An enormous quantity is annually produced at this place, but the provision may be almost deemed inexhaustible.

The origin of coal presents a subject of some difficulty, but it is now generally deemed to be vegetable. The lignite or the fossilised wood retains its texture, and passes gradually into jet. Of this there are curious specimens at Bovey Tracy, in Devonshire, in the north-east of Ireland, and on the Rhine, between Cologne and Bonn. The action of water on turf or wood is sufficient to convert them into substances capable of yielding bitumen in distillation. This action, after a long continuance, may have produced the brown coal of Bovey; and when we see reeds filled and surrounded with sandstone, having the scaly bark converted into a true coal, its vegetable origin seems scarcely to be questioned. The same is true of impressions found in slate clay reduced to common coal. The vestiges of vegetables in coal measures increase in abundance as we approach the strata of coal; so that the vegetable matter which produced the coal was probably in a state of paste, and elaborated by suitable agents amidst the waters of the primeval deluge.

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## THE ATMOSPHERE.

The atmosphere is one of the most essential appendages to the globe we inhabit, and exhibits a most striking proof of Divine skill and omnipotence. It is now ascertained to be a compound substance, formed of different ingredients, termed oxygen and nitrogen gas. Of one hundred measures of atmospheric air, twenty-one are oxygen, and seventy-nine nitrogen. The one, namely oxygen, is the principle of combustion. It is absolutely necessary for the support of animal life, and is the most powerful and energetic

agent in nature. The other (nitrogen) is altogether incapable of supporting either flame or animal life. But the term atmosphere is also applied to the whole mass of fluids, consisting of air, vapours, electric fluid, and other matters, which surround the earth to a certain height. This mass of fluid matter gravitates to the earth,—revolves with it in its diurnal rotation, and is carried along with it in its course round the sun every year. It has been computed to extend about forty-five miles above the earth's surface, and presses on the earth with a force proportioned to its height and density. From experiments made with the barometer it has been ascertained that it presses with a weight of about fifteen pounds on every square inch of the earth's surface; and, therefore, its pressure on the body of a middle-sized man is equal to about thirty-two thousand pounds, or fourteen tons avoirdupois—a pressure which would be insupportable, and even fatal, were it not equal on every part, and counterbalanced by the spring of the air within us. The pressure of the whole atmosphere upon the earth is computed to be equivalent to that of a globe of lead, sixty-six miles in diameter; in other words, the whole mass of the air which surrounds the globe compresses the earth with a force or power equal to that of five thousand millions of millions of tons. This amazing pressure is, however, essentially necessary for the preservation of the present constitution of our globe, and of the animated beings which dwell on its surface. It prevents the heat of the sun from converting water and all other fluids into vapour; and preserves the vessels of all organised beings in due tone and vigour. Were the atmospherical pressure entirely removed, the elastic fluids contained in the finer vessels of men and other animals would inevitably burst them, and life would become extinct; and most of the substances on the face of the earth, particularly liquids, would be dissipated into vapour. Besides these the atmosphere possesses a great variety of other admirable properties, of which the following may be mentioned. It is the vehicle of smells, by which we become acquainted with the qualities of the food which is set before us, and learn to avoid those places which are damp, unwholesome,

and dangerous. It is the medium of sounds, by means of which knowledge is conveyed to our minds. Its undulations, like so many couriers, run for ever backwards and forwards, to convey our thoughts to others, and theirs to us, and to bring news of transactions which frequently occur at a considerable distance. A few strokes on a large bell, through the ministration of the air, will convey signals of distress, or of joy, in a quarter of a minute, to the population of a city containing a hundred thousand inhabitants. It transmits to our ears all the harmony of music, and expresses every passion of the soul; it swells the notes of the nightingale, and distributes alike to every ear the pleasures which arise from the harmonious sounds of a concert. It produces the blue colour of the sky, and is the cause of the morning and evening twilight, by its property of blending the rays of light, and reflecting them in all directions. It forms an essential requisite for carrying on all the processes of the vegetable kingdom, and serves for the production of clouds, rain, and dew, which nourish and fertilise the earth. In short, it would be impossible to enumerate all the advantages we derive from this noble appendage to our world. Were the earth divested of its atmosphere, or were only two or three of its properties changed or destroyed, it would be left altogether unfit for the habitation of sentient beings. Were it divested of its undulating quality, we should be deprived of all the advantages of speech and conversation; of all the melody of the feathered songsters, and of all the pleasures of music; and, like the deaf and dumb, we could have no power of communicating our thoughts but by visible signs. Were it deprived of its reflective powers, the sun would appear in one part of the sky of a dazzling brightness, while all around would appear as dark as midnight, and the stars would be visible at noonday. Were it deprived of its refractive powers, instead of the gradual approach of the day and the night, which we now experience, at sunrise we should be transported all at once from midnight darkness to the splendour of noonday, and at sunset should make a sudden transition from the brilliancy of day to all the horrors of midnight, which

would bewilder the traveller in his journey, and strike the creation with amazement. In fine, were the oxygen of the atmosphere completely extracted, destruction would seize on all tribes of the living world throughout every region of earth, air, and sea.

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## Exercise in Meanings and Derivation.—XVII.

*Divide and accentuate each word, and give its meaning and derivation.*

| | | |
|---|---|---|
| **appendages** | **counterbalanced** | **undulations** |
| **omnipotence** | **equivalent** | **couriers** |
| **ingredients** | **compresses** | **transactions** |
| **principle** | **amazing** | **ministration** |
| **energetic** | **prevents** | **transmits** |
| **agent** | **converting** | **harmonious** |
| **gravitates** | **tone** | **requisite** |
| **revolves** | **inevitably** | **processes** |
| **diurnal** | **extinct** | **enumerate** |
| **rotation** | **dissipated** | **sentient** |
| **density** | **vehicle** | **melody** |
| **avoirdupois** | **unwholesome** | **refractive** |
| **insupportable** | **medium** | **bewilder** |

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## Note.

For information in detail on the "Mechanical Properties of the Atmosphere," see John Heywood's "Class-Book of Modern Science," chapter 4.

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# IRON AND STEEL.

### PART I.

### Glossary of Scientific Terms, &c.

**con-struc′-tion**..........*act of making, putting together, or manufacture.* [Lat. CON, together; STRUO, I build; participle, STRUCTUS, built.]

**cu′-li-na-ry** ...*of or belonging to the kitchen or cooking.* [Lat. CULINA, a kitchen.]

**de-tect′-ed**......*found out, as it were by uncovering.* [Lat. DE, from; TEGO, I cover; participle, TECTUS, covered.]

**duc′-tile**......*capable of being drawn out to great length.* [Lat. DUCTILIS, easily led or drawn; from DUCO, I lead.]

**me-te-or′-ic**......*belonging to a meteor, a fiery appearance in the air.* [Gr. META, beyond; AEIRO, I suspend, a meteor having the appearance of being suspended in the air.]

**smelt-ing**.........*reducing to a liquid state by the action of intense heat.* [Dutch, SMELTEN, to melt.]

**pud′-dling**...........*the process adopted for removing impurities from cast iron to convert it into wrought iron.* [Dutch, PUDEL, to make a stir.]

**im-pu′-ri-ties**........*substances tending to make anything less clean or less valuable.* [Lat. IN, not; PURUS, clean or pure.]

**slag**......*the dross of any metal combined with earthy matter.* [Swedish, SLAGG, to cast off.]

**fur′-nace** ....*an enclosed fire-place used for melting ores.* [Lat. FORNAX, an oven.]

**brit′-tle**......*that which can be easily broken.* [Ang.-Sax. BRYTAN, to break.]

**tem′-pered**.. ......*brought to a proper degree of hardness.* [Lat. TEMPERO, I govern or restrain.]

**mon-op′-o-ly**.....*the sole power of making or selling anything.* [Gr. MONOS, alone; PŌLEO, I sell.]

**re-sid′-u-um**...........*anything which remains after any chemical operation or process of purification.* [Lat. RESIDEO, I remain behind.]

**es′-ti-mate**....*value, determine by consideration or calculation, to judge of the worth or size of anything.* [Lat. ÆSTIMO, I value.]

Of all the substances with which we are made acquainted by geology and chemistry, none are more important to us than iron. In various states it is employed in the construction of utensils and instruments required in culinary operations. Saucepans, kettles, and pans are frequently made of cast iron; bolts, irons, and their heaters, and other things, of wrought iron; and fire-irons of steel. A short account of this metal, and the processes it undergoes to fit it for manufacture, will not, therefore, be unimportant.

Iron is almost universally diffused through nature: it has been detected in plants and animal fluids; it forms the colouring matter of many substances, and is extensively distributed in some parts of the mineral series. It is a malleable metal, so ductile that it may be beaten out into a wire finer than the human hair, and may be permanently united or welded by forging. The ores of iron are numerous. The meteoric stones always contain a proportion of

iron ; one of these fell near Agram, in Croatia, in the year 1751, and was found to consist of 96·5 per cent of iron and 3·5 of nickel. A mass of the same kind found in South America, and supposed to weigh 30 tons, consisted of 90 parts of iron ; and that which has been observed in the desert of Sahara has 96 per cent of the same metal.

When the ore of iron is collected it is not in a state fit for use ; the extraneous substances with which it is connected must be removed, and this is done by smelting. The bottom of the furnace is first filled with fuel ; the ore is then broken into small pieces and mixed with lime, to render it more capable of fusion ; it is then thrown into the furnace, with a certain proportion of charcoal or coke. When the fire is kindled the combustion is aided with a pair of large bellows, and a most intense heat is quickly produced by the blast ; the ore nearest to the fire is soon melted, and falls to the bottom through the fuel, where it is collected ; that which rests upon it sinks into its place, and is melted in the same manner. Fresh ore and fuel are then added, and the process continued till the melted metal, rising nearly to the height of the nozzle of the bellows, is let off into moulds prepared for that purpose The casts are called pigs, and are ready for the use of the caster.

Cast iron is converted into wrought iron by a refining process called puddling. The cast iron contains a large quantity of carbon and other impurities, of which it must be divested to render it thoroughly malleable. For this purpose the iron is melted in a furnace, and kept in a state of fusion for a considerable time, and repeatedly stirred. The carbon is thus made to combine with the oxygen of the atmosphere, forming carbonic acid, while a part of the oxide of iron, united with the earthy matter, rises to the surface as a slag. The melted mass of iron then begins to get thicker, and is removed from the fire. It is then subjected to the beating of large hammers, or the pressure of rollers, by which a portion of the impurities are, in fact. squeezed out. After passing through this process it becomes malleable iron, and is brought into the market either in bars or rods ; but, during the progress of the

manufacture, it loses weight from the oxidising of the surface, scaling, and the diminution of the impurities. In purchasing wrought iron the workman distinguishes two kinds, which are both of very inferior value; they are called hot-short and cold-short iron. The former is a fusible metal, which possesses ductility when cold, but is so brittle when heated that it will not bear the stroke of the hammer; the cause of this variety is not known. The latter kind is very malleable and ductile while hot, but the utensils made with it are as brittle as cast iron when cold: such iron contains a portion of phosphate of iron.

The process of making steel may now be noticed: When wrought iron is slowly heated in contact with charcoal, it takes up a portion of carbon and gives off oxygen, by which it is formed into steel. Cast iron also contains carbon, but steel differs essentially from that substance in being divested of its oxygen and earthy matter. When only a small quantity of carbon is united with the iron, the metal does not lose its malleability: when a large quantity is given, it can no longer be welded. To determine which is iron and which is steel, of two pieces of metal, it is only necessary to drop a little nitric acid on each, and a black stain will be produced on the surface of the polished steel, but not on the iron. When steel is raised to a high temperature and suddenly cooled, it becomes exceedingly brittle, and, in fact, unfit for manufacture. It is therefore tempered by the workman, or, in other words, brought to the requisite degree of hardness, of which an experienced person may judge by the colour.

Cast steel is made by fusing iron at an intense heat with carbonate of iron. This substance contains more carbon than common steel, but its manufacture was a long time considered as a secret. The process, however, is now well understood, and there can be, in the present day, no reason for a monopoly; which, indeed, does not exist.

Steel was supposed to be a carburet of iron—a compound of iron and carbon. But pure steel may be dissolved in acids without any residuum, and it is thought that it obtains its peculiar properties from a singular crystallisation, and not from its chemical composition

During the last few years the consumption of iron has been greatly increased. It is almost impossible to estimate how much our domestic comforts depend on the manufacture of iron, or how much the commerce of this country is indebted to the facilities of obtaining the ore. The introduction of railways in all parts of the United Kingdom and the building of iron ships have proved a new and very large source of consumption; to which may be added the tramways or iron roads, for cars to convey passengers, which have already been laid in many parts of London, and soon will become common in all our great cities. The same works are going on in America, many of the European states, and even in Egypt, India, and South America. Some of these we are supplying with the requisite rails, and nearly all of them with machines. If, then, we view our home and foreign trade in this one article, we may form some estimate of the great abundance of the ores of iron in our own country, and also the facilities we possess of smelting it, from the abundance of coal near to those spots where the iron is chiefly obtained.

## IRON AND STEEL.

### PART II.

Cast iron and steel are more frequently used for domestic purposes than that which is wrought; kettles, pans, saucepans, some fenders, and other articles are made of cast iron.

The simplest method of casting is the following: A model is first formed, and an impression is taken upon sand contained in two open frames; when the mould is made the two frames are put together, and the melted pig-iron is poured in through a channel left for that purpose.

When iron is exposed to a damp atmosphere, and especially when there is an alternate exposure to water and air, it slowly combines with oxygen, or, in other words, rusts. This effect is also produced by raising the temperature: when a bar of iron is kept for some time at a red

heat, it is covered over with a coating of the oxide of iron, and when forged, thin plates are thrown off from the surface.

All those kitchen utensils used for boiling water and other culinary purposes are peculiarly exposed to oxidisation, and there would, consequently, be a great difficulty in keeping them clean if there were not some method of preventing the effect altogether. This is done by a process called tinning; and where iron cannot be used tin is employed; thus we have what are termed tin tea-kettles, tin saucepans, and other articles. But it must not be supposed that these utensils are actually formed of tin; they consist of thin plates of iron, covered with a coating of tin, or, more properly, made to combine with a portion of tin. This is done in the following manner: the iron plate is first thoroughly cleaned, being well rubbed with sand, and then steeped in very diluted muriatic acid; after being baked to remove the scales, the plates are hammered, and passed through rollers. When thus prepared, they are dipped into a chemical composition called sours, and afterwards into melted tin, which unites with the iron. These tin plates are sold by the retail ironmongers, and converted into various instruments and utensils.

Copper vessels are sometimes used in cooking, and they are almost always tinned, for when they are not kept clean a greenish-blue rust is formed, which, if mixed with food and taken into the stomach, becomes dangerous to life. Many instances of poisoning from this cause are recorded. It is not, however, generally known that fatty substances and vegetable acids do not attack copper while hot; if, therefore, the liquid be emptied from the vessel while hot no danger will be incurred, but if it should remain in the vessel till cold the carbonate of copper is then formed. To prevent all chance of danger copper vessels should always be tinned, and this is generally done; but, after being in use some time, the tin wears off, and the process should be repeated.

There is one other property which may be communicated to iron and steel, of which we must speak before we close

this paper. It was known, at a very early period, that a certain ore of iron possessed the property of turning itself to the north and south poles of the earth; this is called its magnetic property, and its principles of action are now so well known that the navigator feels no fear in trusting the safety of his vessel to its guidance. The magnetism of iron may be communicated from one substance to another in a variety of ways. If a magnet be placed in contact with a piece of iron, it communicates to the ferruginous body the same property; so, if a bar of iron be rubbed with a magnet, it receives the magnetic principle. Pieces of iron used in the construction of buildings, and in a vertical position, are generally magnetic. When lightning passes through an iron bar, it acquires the same property, and a poker is seldom altogether destitute of it. If the poker should be found, on experiment, to have no magnetism, it may be easily introduced by holding it with the point downwards, and striking upon the head with a hammer several times.

When an end of a piece of soft iron is brought near to an end of a magnet, it instantly becomes magnetic, and has all the properties of a lodestone; but, as soon as it is removed from contact, it loses its newly acquired properties, and even if it were rubbed the same result would follow. To form a permanent magnet, steel must be used. The needles used in compasses are formed of this material, and, when properly shaped and hardened, are touched; by which process they are formed into true and permanent magnets.

There are many uses to which iron is applied, of which we cannot speak. The cooper binds his casks with iron hoops; nearly all workmen's tools are formed of iron; and there is scarcely an art, from that which is most refined to that which is most common, in which it is not of importance; and hence it is that the blacksmith will inform you that, of all artisans, he is least dependent on other trades. A blacksmith is to be found in every country village where the farmers' horses may be shod, and their agricultural implements and carts immediately repaired when broken, without loss of time.

## Exercise in Meanings and Derivation.—XVIII.

*Divide and accentuate each word, and give its meaning and derivation.*

| | | |
|---|---|---|
| **domestic** | **exposed** | **navigator** |
| **articles** | **preventing** | **contact** |
| **impression** | **thoroughly** | **ferruginous** |
| **channel** | **steeped** | **permanent** |
| **alternate** | **diluted** | **compasses** |
| **exposure** | **poisoning** | **hardened** |
| **combines** | **emptied** | **refined** |
| **temperature** | **incurred** | **importance** |
| **forged** | **magnetic** | **artisans** |
| **utensils** | **agricultural** | **implements** |

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## THE BAROMETER.

### Glossary of Scientific Terms, &c.

**ba-rom-e′-ter**........*literally a weight measurer, an instrument which shows the variations in the pressure of the atmosphere.* [Gr. BARUS, heavy ; METREO, I measure.]

**mer′-cury**....*a white poisonous metal, also called quicksilver.* [Lat. MERCURIUS, the heathen god of merchandise.]

**im-mersed′**..........*plunged or dipped into.* [Lat. IN, into ; MERGO, I plunge ; MERSUS, plunged.]

**va′-cant**....*empty, unoccupied.* [Lat. VACUUS, empty.]

**re-lieved′**........ ...*freed from, unburdened.* [Lat. RE, again ; LEVO, I lighten or raise.]

**grad′-u-a-ted**........*marked by lines at regular intervals.* [Lat. GRADUS, a step.]

**sus-pend′-ing**......*hanging up.* [Lat. SUB, beneath ; PENDO, I hang.]

**sus-tains′**.........*holds up, supports.* [Lat. SUB, under ; TENEO, I hold.]

**sa-lu′-bri-ous**..........*healthy, wholesome.* [Lat. SALUBRIS, healthy ; from SALUS, health.]

**cir′-cu-late** .....*move from the heart through the arteries and back to the heart through the veins.* [Lat. CIRCULO, I move in a circle.]

**im-preg′-na-ted**..........*interspersed, intimately mingled with.* [Lat. IN, into ; and PRÆGNANS, pregnant.]

**ob-struc′-tions**....*hindrances, impediments, anything standing in the way.* [Lat. OB, against ; STRUO, I build or pile up.]

**rare**......*thin, less dense.* [Lat. RARUS, thin, subtle.]

**el-e-va′-tion**......*height above the surface of the earth.* [Lat. E, from ; LEVO, I raise.]

**in-di-ca′-tions**.......*marks by which anything is shown or taught.* [Lat. IN, intensive; DICO, I say or tell.]

**ex-pe′-ri-enced**......*gained by trial or observation.* [Lat. EXPERIOR, I make trial of.]

**ex-ha-la′-tions**.........*vapours rising from the earth's surface, caused chiefly by heat.* [Lat. EX, from; HALO, I breathe.]

**in-ten′-si-ty**.............*extreme power.* [Lat. IN, towards; TENDO, I stretch; participle, TENSUS, stretched.]

**se-ver′-i-ty**.........*inclemency, sharpness.* [Lat. SEVERUS, grave; AUSTERE, strict.]

**in-verse′-ly**.......*in the reverse or contrary order.* [Lat. IN, opposite or against; VERTO, I turn.]

A barometer is an instrument which indicates the state of the weather, by showing the weight of the atmosphere. It is extremely simple in its construction, and consists of a glass tube, about three feet in length, open only at one end. This tube must first be filled with mercury, then, stopping the open end with the finger, it is immersed in a cup, which contains a little mercury. Part of the mercury which was in the tube now falls down into the cup, leaving a vacant space in the upper part of the tube, to which the air cannot gain access. This space is, therefore, a perfect vacuum, and consequently the mercury in the tube is relieved from the pressure of the atmosphere, whilst that in the cup remains exposed to it; therefore, the pressure of the air on the mercury in the cup supports that in the tube, and prevents it from falling: thus the equilibrium of the mercury is destroyed only to preserve the general equilibrium of fluids. This simple apparatus is all that is essential to a barometer. The tube and the cup, or vase, are fixed on a board, for the convenience of suspending it; the board is graduated for the purpose of ascertaining the height at which the mercury stands in the tube; and a small movable metal plate serves to show that height with great accuracy. The weight of the atmosphere sustains the mercury at the height of about 29½ inches; but the exact height depends upon the weight of the atmosphere, which varies much according to the state of the weather. The greater the pressure of the air on the mercury in the cup, the higher it will ascend in the tube. The air, therefore, is generally heaviest in dry weather,

for then the mercury rises in the tube, and consequently that in the cup sustains the greatest pressure; and thus we estimate the dryness and fairness of the weather by the height of the mercury. We are apt to think the air feels heavy in bad weather, because it is less salubrious when impregnated with damp. The lungs, under these circumstances, do not play so freely, nor does the blood circulate so well; thus obstructions are frequently occasioned in the smaller vessels, from which arise colds, asthmas, agues, and fevers.

As the atmosphere diminishes in density in the upper regions, the air must be more rare upon a hill than in a plain; and this difference may be ascertained by the barometer. This instrument is so exact in its indications that it is used for the purpose of measuring the height of mountains, and of estimating the elevation of balloons. Considerable inconvenience is often experienced from the thinness of the air in such elevated situations. It is sometimes oppressive, from being insufficient for respiration, and the expansion which takes place in the more dense air contained within the body is often painful; it occasions distension, and sometimes causes the bursting of the smaller blood vessels in the nose and ears. Besides, in such situations, the body is more exposed both to heat and cold; for though the atmosphere is itself transparent its lower regions abound with vapours and exhalations from the earth, which float in it, and act in some degree as a covering, which preserves us equally from the intensity of the sun's rays and from the severity of the cold.

Now, since the weight of the atmosphere supports mercury in the tube of a barometer it will support a column of any other fluid in the same manner; but as mercury is the heaviest of all fluids it will support a higher column of any other fluid, for two fluids are in equilibrium when their heights vary inversely as their densities; as, for instance, if a cubic foot of one fluid weighs twice as much as a cubic foot of the other, a column of the first, ten feet in height, will weigh as much as a column of the other twenty feet in height. Thus the pressure of the atmosphere, which will sustain a column of

mercury of twenty-nine inches, is equal to sustaining a column of water of no less than thirty-four feet above its level. The weight of the atmosphere is, therefore, as great as that of a body of water surrounding the globe of the depth of thirty-four feet, for a column of air of the height of the atmosphere is equal to a column of water of thirty-four feet, or one of mercury of twenty-nine inches, each having the same base.

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### Note.

For further information respecting the construction, properties, and uses of the barometer, see John Heywood's "Class Book of Modern Science," page 77.

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## SPERMACETI AND AMBERGRIS.

### GLOSSARY OF SCIENTIFIC TERMS, &C.

**co-los′-sal**...*of immense size.* [Lat. COLOSSUS, any statue larger than life, but more especially that which stood at the entrance to the harbour of Rhodes.]

**ad′-i-po-cere**.......*a substance partly like fat and partly like wax.* [Lat. ADEPS, fat; CERA, wax.]

**ce-ta′-ce-a**......*an order of the class mammalia, including the whales.* [Lat. CETE, a whale.]

**blub′-ber**.....*coarse, oily, fat.* [A name said to be an imitation of the noise made by shaking air and water together.]

**lam′-i-næ**.........*thin plates or layers.* [Lat. LAMINA, a thin plate of metal.]

**sper-ma-ce′-ti**.........*a waxy matter from the head of the sperm whale.* [Lat. SPERMA, seed or spawn; CETE, a whale.]

**co-ag′-u-lates** ..*thickens into a solid or partially solid mass.* [Lat. COAGULUM, a curd mass; from CON, together, AGO, I drive.]

**pos-te′-ri-or-ly**...*towards the rear or behind.* [Lat. POSTERUS, coming after.]

**in-teg′-u-ments** ...... *natural coverings that lie over anything beneath.* [Lat. IN, on or upon; TEGO, I cover.]

**crude**.........*raw, in a natural state.* [Lat. CRUDUS, raw, uncooked.]

**sa-po-na′-ce-ous** ...... *soapy, having a soap-like appearance.* [Lat. SAPO, soap.]

**con-gealed′**...........*hardened together into a solid mass, as ice by frost.* [Lat. CON, together; GELU, frost.]

**e-mul′-sion**...*a milk-like fluid obtained by mixing oil and water together with a substance that unites with both.* [Lat. E, from or out; MULGEO, I milk.]

**bleach′-es**.. *whitens, deprives of colour.* [Ang.-Sax. BLÆC, pale.]

**fri′-a-ble**......*easily reduced to powder by rubbing.* [Lat. FRIO, I crumble.]

**vol′-a-tile**...*apt to waste away or fly off by evaporation.* [Lat. VOLO, I fly.]

**pet-ro′-le-um**......*rock oil or mineral oil.* [PETRA, a rock; OLEUM, oil.]

**ar-o-mat′-ic**.........*exhaling a sweet and pleasant odour.* [Gr. AROMA, a pleasant smell.]

**re-ten′-tion** ...... *keeping or holding back, restraint.* [Lat. RE, back; TENEO, I hold.]

**e-ma′-ci-a-ted**......*thin, lean, wasted by hunger.* [Lat. MACIA, leanness.]

**mot′-tled**...*marked with spots.* [Old Eng. SMOTTRED, bedaubed.]

**va′-ri-e-ga-ted**.........*marked with different colours.* [Lat. VARIUS, different; AGO, I make.]

**unc′-tu-ous**......*of a greasy nature, oily.* [Lat. UNGO, I anoint; participle, UNCTUS, smeared.]

There are four valuable articles of commerce which man, by daring industry, obtains from the whale tribe, those colossal tenants of the polar latitudes of the ocean. The four articles to which we allude are oil, adipocere, whalebone, and the substance known under the name of ambergris, *ambre gris.*

Oil is produced in greater or less abundance by all the cetacea, and is procured by melting the blubber which invests their bodies.

The whalebone, which is in the form of sub-triangular plates, having their free edge fringed with coarse, horny fibres, a subdivision of the fibres of the plate, is attached transversely to the palate of the whale, in a row on each side. The palate of the whale is oval, resembling a reversed boat, whence it necessarily follows that the laminæ in the centre are the longest. Some have been known to measure twenty-five feet in length; the whale-fishers, however, regard the whale as full-sized where they measure six feet one inch; but ten, twelve, and fifteen feet are frequently the length of the laminæ of baleen in larger

animals. The toughness, the texture, the elasticity, and the general uses to which baleen is applied are known to all.

It is, however, more especially to the substances denominated adipocere and ambergris that we now invite our readers' attention, as well as to the extraordinary animal producing them, a sketch of whose history we shall give in the next lesson.

Adipocere is that substance commonly known under the name of spermaceti, and used both in medicine and in the manufacture of candles. It is termed cetine by M. Chevreul, who classes it among animal oils: in commerce it occurs in the form of glossy white semi-transparent flakes, easily reducible to powder. It melts at 112 degrees, and may be distilled without experiencing any material change; about 150 parts of alcohol, in a boiling state, dissolve one of cetine, which, however, is again deposited as the solution cools.

Spermaceti is not, as it has been supposed by some, the brain of the cachalot whale, but it is a peculiar concretion of an oily fluid, which fills certain cavities of the huge skull of this gigantic animal. Cuvier observes that "the upper part of the enormous head of the cachalot consists of large cavities, or cells, covered and separated by cartilage, and filled with an oil which coagulates as it cools. But these cavities are very different from the true skull, which is somewhat small, situated beneath them posteriorly, and contains the brain as usual. It would appear that these canals, filled with this spermaceti, or adipocere, are distributed over most parts of the body communicating with the cavities which fill the mass of the head; they interlace also through the ordinary blubber, which is spread under the whole of the skin." Count Lacepéde also observes that the huge head of the cachalot encloses, on its upper portion, a vast cavity very distinct from that which contains the brain, and which is very small: it is covered externally by integuments, such as a layer of fat or blubber and the skin, and is divided into two portions, an upper and a lower, by a horizontal membrane, both being traversed by the blow-holes: the lower, which is immediately over the palate-bones, is the largest; but each

is subdivided into a multitude of cells by their vertical membranes, and in these is the adipocere contained.

This substance during the life of the animal is fluid, and it remains so for a short time after it is extracted from the head of the cachalot when dead; in proportion, however, as it cools, it coagulates. If it be mixed with a certain quantity of oil, it requires cooling down more considerably before it becomes fixed or congealed, from the vast reservoir of the head alluded to. Lacepéde also notices the prolongation of a canal down the body, communicating with smaller canals and cavities, which interlace with each other, and are distinguished throughout the blubber. The quantity of crude spermaceti which this great cavity and its accessory canals, in a full-sized cachalot, will yield, amounts from twelve to eighteen or twenty barrels. It has, however, to be purified before being fitted for general use. The process is very simple: Being put into hair bags, it is pressed between the plates of an iron screw press, in order that every portion possible of oil may be squeezed out and drained away. It is then boiled in water, in which it becomes melted, and is thus freed from other impurities, which rise to the top if oily, or sink to the bottom if merely consisting of accidental matters. On cooling it again coagulates, separating from the water. It is then boiled afresh in a weak alkaline lye, the potash of which combines with it, and throws it into a saponaceous condition; this process is repeated once or twice more, until the requisite point be attained. The mass now assumes a flaky structure as it cools, and is separated with a wooden knife into small thin portions for convenience. It is in this saponaceous state that it is usually sold in the druggists' shops: without being thus treated it would not blend with water, so as to make what is termed an emulsion.

With respect to pure cetine, Fourcroy, the celebrated chemist, states that "nitric and muriatic acids have no action on it; concentrated sulphuric acid dissolves it, at the same time altering its colour: from this solution water separates it, as it precipitates camphor from nitric acid. Sulphuric acid deprives it of colour and bleaches it; oxygenated muriatic acid turns it yellow, but when it has

naturally assumed this tint does not increase it. The lyes of fixed alkalies unite with it when liquefied, and render it saponaceous ; this kind of soap dries and becomes friable."

We shall not, however, enter into chemical details connected with it : we may observe, however, that Fourcroy regards cetine as a peculiar substance, which may perhaps be considered as having the same relationship to the fixed oils, namely, suet, lard, &c., which camphor bears to the volatile oils, while wax would appear to be to these same fixed oils what resin is to the volatile oils. In concluding our observations on spermaceti, or *cetine*, we may add that the oil obtained from the substance during the process of draining and pressing it is remarkably thin ; indeed, it is the thinnest of animal oils, and burns with a pure flame ; hence it is used for lamps.

The next product of the cachalot which we noticed is ambergris, or, as it is often written, ambergrease. This substance, well known as a perfume and celebrated for its musky odour, remained for a long time without its true nature being ascertained. Some naturalists have regarded it as a mineral oil, a sort of bitumen or petroleum, which thickened by the heat of the sun, and hardened by long subjection to the action of the salt water, was swallowed by the cachalot, and modified in its stomach by the process of digestion; others observing in it beaks like those of birds (the beaks of little fish in fact), have conjectured that it was the product of aromatic herbs swallowed and digested by birds ; others, that it was a frothy substance produced by the seal; and others again, that it was a mixture of wax and honey, so modified by the sun and the salt water as to become aromatic. In all these hypotheses the cachalot was considered as having swallowed it, as chance brought it within his reach. While thus floating in a soft state on the surface of the ocean, it was supposed to become mingled with fragments of beaks, with scales of fishes, bits of shells, and other foreign matters, and in this manner their presence was accounted for. The fact is, that ambergris is the digested food of the cachalot, altered by long retention in the alimentary canal of the animal, in a sickly or diseased condition. Its lightness

occasions it to float on the water, and thus it is drifted by currents in masses of various size over the expanse of the ocean, till it becomes thrown up on the beach or driven into tranquil bays and inlets. It is also taken in large quantities from the intestines of cachalots, whose sickly and emaciated appearance is an almost unfailing symptom of its presence. Thus obtained, its consistence is much softer than it is when found floating on the sea or cast on the shore, but it soon hardens and becomes brittle. It is usually of a whitish colour—hence the term *gris* or gray; sometimes it is mottled or variegated with a darker tint; it is opaque, inflammable, very light, and on being heated gives out a musky odour. When scraped with a knife it adheres to the edge like wax; its specific gravity varies from 780 to 926. At 122 it melts, and at 212 it is volatilised. It is insoluble in water; but alcohol and the volatile oils dissolve it. With alkalies it forms a soap, soluble in water. According to Le Grange, it consists chemically of 527·7 adipocere, 30·8 resin, 5·4 charcoal. It is softened by moderate heat, and becomes unctuous; on red hot metal, or on being touched with a lighted candle, it burns with a bright flame, and consumes utterly away. Besides the ambergris which is obtained by the whale-fishers directly from the intestines of the cachalot, vast quantities of the floating material are also collected, as well as of that thrown on various coasts, especially of the Bahamas and other islands. It appears to be indeed almost universally dispersed; it has been found on the coast of Japan, in the Chinese sea, in the great gulf of India, and among the islands of the Indian archipelago, on the coasts of New Holland, Madagascar, Africa, Mexico, Brazil, the Bahama Islands, and Providence Island. It has also been found on the coast of Gascony, &c. Its use in Europe is confined entirely to the preparation of perfumery; it has, however, been tried as medicine, especially in convulsions and similar diseases, and, according to some writers, with great success. We are told that in some parts of Asia and Africa it is used as a condiment in cooking. Large quantities are purchased by the pilgrims visiting Mecca, in order to burn as incense.

## Notes.

1. CHEVREUL, Michael Eugene, a distinguished French chemist and natural philosopher, whose peculiar researches procured for him the name of the "Father of the fatty acids." He was also famous for his studies of the laws of the harmony and contrast of colours, which he embodied in two works, "The Law of Contrast of Colours," and "Memoirs on Colours." He was born in 1786.

2. FOURCROY, Antoine François de, like the preceding, was famous as a chemist and natural philosopher, and wrote many valuable works in connection with his favourite studies. In 1799, he became minister of public instruction under Bonaparte. He was born in 1755, and died in 1809.

3. LACEPÉDE, Bernard Germain de, a distinguished French naturalist, who was in early life keeper of the cabinets in the Jardin du Roi (King's garden), Paris. He became president of the senate under Bonaparte, and grand chancellor of the Legion of Honour; but after the restoration of the Bourbons he resumed his studies in natural history. He wrote a "Natural History of Whales," and other works. He was born in 1756, and died in 1825.

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## THE CACHALOT WHALE.

Having in the preceding lesson briefly described the nature and properties of spermaceti and ambergris, let us now turn to the gigantic animal of which these substances are the production. The cachalot belongs to a genus of the *cetacea*, termed *physeter*, distinguished by a very large head, excessively swollen on its anterior part, which is occupied by the great reservoir for the adipocere, already alluded to. The upper jaw is destitute of whalebone, but the lower jaw, which is straight and elongated, is furnished with a huge conical tooth, and fits into a groove in the upper jaw; when the mouth is closed these teeth being received into corresponding cavities. But there are also, in general, small teeth in the upper jaw, which appear in the spaces between these cavities; they are about twenty in number. There is no dorsal fin, its place being supplied by a callous ridge, terminating abruptly. The eye is placed higher than in most of the large cetacea; it is

black, and that on the left side is smaller than the other. The fishermen always choose this side, if possible, on which to attack the animal, averring that the sight of this eye is also less distinct. The blow hole is a single orifice, and directed towards the left side, terminating on the anterior part of the muzzle, which is truncate. The want of exact symmetry between the two sides of the scull, as indicated by the smallness of the left eye and the inclination of the blow hole to that side, appears to obtain throughout the cetacea in general.

It has been noticed by Cuvier and Dr. Grant, in his "Outlines of Comparative Anatomy," observes respecting the cetacea, "the right side of the head is generally more developed than the other, and the nostrils are inclined to the left side." It is not, therefore, without reason that the whalers regard the vision of the left eye of the cachalot as imperfect. The orifice of the ear is scarcely to be found; it is situated in an excrescence of the skin between the eye and the ear.

Of enormous size, strength, and activity, the cachalot is formed to be the tyrant of the deep. He roams through every latitude, spreading terror and consternation around him; the largest fishes flee before him; the terrible shark is panic-struck at his approach, and plunges into the lowest deep, tries to hide itself amidst the mud or sand at the bottom, dashes over reefs, throws itself against rocks with such violence as sometimes to produce death, and, as it is said, dares not even approach the dead body of its foe, much as it feeds upon the flesh of other cetacea. Seals, porpoises, and dolphins alike dread the cachalot; tyrants as they are, before this mighty conqueror they shrink with terror, and are chased by him as sheep by the wolf, and fall an unresisting prey. In fact, the cachalot is the tiger of the ocean; cuttle-fish and other *mollusca* he devours by myriads, and makes tremendous havoc among the larger kind of fishes, and other formidable tenants of the deep. Unlike the peaceful, timid, though gigantic Greenland whale (*balæna mysticetus*), he fears no enemy—he attacks every foe with undaunted energy and unsparing ferocity.

It is not only on the northern seas that the cachalot occurs: this animal visits the shores of southern Europe, and advances up the Mediterranean; it roams through the great Atlantic, and has been seen off the shores of southern Africa, and in the channel of Mozambique; it occurs in troops in the southern ocean, and within the regions of the antarctic circle. It is said that the neighbourhood of the Gallapagos constitutes a sort of rendezvous in spring for all the cachalots frequenting the coasts of Mexico, Peru, and the gulf of Panama.

The affection of the females of the whale tribe for their young has long been celebrated; and many affecting narratives of the self-devotion of the mother in defence of her cub are on record, and well established. In this point the cachalot yields to none; it is said even to exceed them all; but this is doubtless to be attributed to its more daring disposition and more formidable weapons. It is on record that once, in Brazilian waters, a large whale, of the cachalot species, seeing its young one captured by the fishers, dashed with such fury against their boat as to upset it, the cub and the sailors being alike thrown into the water; the mother took the cub under her protection and swam away, and the men were not saved without the greatest difficulty.

In 1784, thirty-two cachalots ran aground on the coast of Audierne, being stranded on the sands called *Tres Conaren;* the interesting details connected with which circumstance were published in a French magazine.

It appears that on the 13th of March persons saw, with great surprise, vast shoals of fishes throw themselves on the shore, and a great number of porpoises enter the port of Audierne. On the 14th, at six in the morning, the sea was high, and the winds blew from the south-east with violence. Towards Cape Estain were heard extraordinary bellowings, which resounded far along the land. Two men who were coasting along the shore were terror-struck, especially when they saw, a little out at sea, enormous animals plunging about with violence, straining to resist the foaming waves which carried them on towards the shore, making the surges roar with redoubled blows of

their tails, and throwing through their nostrils columns of water with a loud, hissing noise. On, however, they were driven, struggling with mighty but unavailing strength and fury against the tide; and, to the consternation of the spectators, were stranded on the sand-bank, where they lay rolling and dashing about for twenty-four hours, until at length they perished. Many other similar instances are upon record.

The species of cachalots (*physeter*) are by no means well understood. We only know one with any degree of certainty, namely, the blunt-headed cachalot (*physeter macrocephalus*), the other assumed species of the genus being imperfectly characterised, and resting on doubtful authority.

The cachalot attains to the length of sixty-three or sixty-four feet; its general colour is black, or dusky, somewhat paler beneath. The *physeter trumpo* of authors, and supposed by them to be a distinct species, is identical with the *physeter macrocephalus*.

## Exercise in Meanings and Derivation.—XIX.

*Divide and accentuate each word, and give its meaning and derivation.*

| | | |
|---|---|---|
| **gigantic** | **terminating** | **ferocity** |
| **anterior** | **abruptly** | **rendezvous** |
| **reservoir** | **formidable** | **enormous** |
| **elongated** | **undaunted** | **symmetry** |
| **consternation** | **protection** | **inclination** |
| **unresisting** | **averring** | **orifice** |
| **captured** | **muzzle** | **excrescence** |
| **corresponding** | **truncate** | **devotion** |
| **dorsal** | **exact** | **disposition** |
| **unavailing** | **assumed** | **perished** |

## Notes.

1. Cachalot. — This term, which is now adopted in science as the name of this species of whale, is the Basque appellation of the animal, which is so called from the enormous tooth which it possesses: *cachau*, in the Basque dialect, meaning tooth. *Balæna*, the Latin for whale, is a generic name applied to the Greenland whale, and all of a similar genus or kind; while *physeter* is the term used both by the Greeks and Latins, or Romans, for the spermaceti whale.

2. Grant, Robert Edmund, an eminent Scotch physiologist and zoologist, the author of "Outlines of Comparative Anatomy," was born in 1793. He was for many years professor of physiology at University College, London; and from 1837 to 1841 was Fullerian professor at the Royal Institution, London.

## THE FIVE ORDERS OF ARCHITECTURE.

### Part I.—The Pedestal, Column, and Entablature.

#### Glossary of Scientific Terms, &c.

**dec-o-ra′-tion**........*ornament, anything that adorns.* [Lat. DECORO, I adorn; from DECUS, grace.]

**ar′-chi-tec-ture**.....*the science or art of building.* [Gr. ARCHOS, chief; TECKTON, a builder.]

**lib′-er-ty**......*freedom of will, speech, or action.* [Lat. LIBER, free.]

**sen-sa′-tions**..........*thoughts, feelings.* [Lat. SENTIO, I perceive.]

**Co-rinth′-i-an**...*of or belonging to* CORINTH, *the city from which this term is derived.*

**com′-po-site**......*put together, formed from others.* [Lat. COM, together; PONO, I place; participle, positus, placed.]

**Dor′-ic**.......*of or belonging to* DORIS, *in Greece, from which the name of this order is derived.*

**I-on′-ic**......*of or belonging to* IONIA, *in Greece, from which the name of this order is derived.*

**Tus′-can**.... .*of or belonging to* TUSCANY,*the ancient Hetruria in Italy, from which the name of this order is derived.*

**col′-umn**......*an upright pillar used to support a building.* [Lat. COLUMNA, a column.]

**en-tab′-la-ture**...*the flat table-like mass that is placed on the top of a series of columns forming the front of the roof of a porch or portico.* [Lat. TABULA, a table.]

**cap′-i-tal**........*the head of a column.* [Lat. CAPUT, a head.]

**ar′-chi-trave**..........*the beam immediately on the top of the column on which the remainder of the entablature rests.* [Gr. ARCHOS, chief; TRABS, a beam.]

**fem′-i-nine**...*womanly, having the delicacy of form and grace of a woman.* [Lat. FŒMINA, a woman.]

**ma-tron′-ly**......*of full womanhood, motherly in aspect.* [Lat. MATER, a mother.]

**frieze**...........*the part of the entablature lying between the architrave and cornice.* [Old Eng. FRISE, nap of cloth, from a similarity between the nap of coarse cloth and the roughness of the frieze which was usually sculptured in figures of low relief.]

**cor′-nice**.. .......*the uppermost part of the entablature.* [Lat. CORONA, a crown.]

**ped′-es-tal**.. ......*the mass of stones or other material on which a column is sometimes placed.* [Lat. PES, a foot; STO, I stand.]

**plinth**...*the projecting member which forms the lowest part of the pedestal.* [Gr. PLINTHOS, a brick, in allusion to its brick-like shape.]

**co-ro′-na**......*the last course of stone on the top of an entablature.* [Lat. CORONA, a crown.]

**mould′-ings**........*ornamental projections, having their sections generally in a curved form.* [Lat. MODULUS, a little measure; from MODUS, a measure.]

**mod′-ule**........*an architectural measurement of thirty minutes in some orders and sixty in others.* [Lat. MODULUS, a little measure.]

**di-am′-e-ter**.........*the measure across a circle from side to side, passing through the centre.* [Gr. DIA, through; METRES, I measure.]

**o′-vo-los**........*egg-shaped ornaments.* [Lat. OVUM, an egg.]

**ca-vet′-to** ....... ...*a moulding hollowed out as if with a gouge.* [Lat. CAVUS, hollow.]

**mas′-cu-line**....*manly, belonging to the male kind, strong and vigorous, after the form of a man.* [Lat. MAS, the male.]

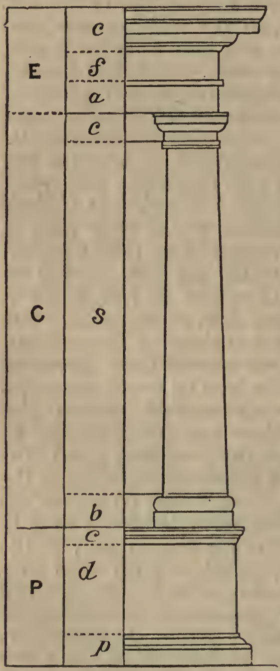
To attempt here to give a reader an insight into the great science of architecture, or indeed into any other science, with the idea of making him a proficient therein, is simply ridiculous. It is impossible to make him acquainted even with the leading principles in their entirety, which form, as it were, the basis or foundation on which the science is built up; but it is possible to call his attention by such means to the nature of the science itself, and to draw his attention to a study whose practisers in all ages have produced noble and well-proportioned buildings, some of which have been aptly spoken of as "poems in stone."

In architecture there are *styles* and *orders*; and it is of the latter that we are now going to speak. The *style* may be defined as the leading fashion of the period during which the building was erected, or the fashion after which

it was built. Thus the Gothic style, broadly speaking, is the style in which Westminster Abbey and most of our fine old English cathedrals are built; and these were erected in mediæval times, when the prevailing taste of men led them to adopt and follow out this grand style in many forms, which bear different names for the sake of due distinction. St. Paul's Cathedral, on the contrary, was built after the Great Fire of London, at a time when architects, turning away from the Gothic style, which had become debased, or lowered from its original beauty and purity of form and grandeur of design, followed the form in some measure after which the old Greek and Roman temples were built, and which, in consequence, was called the classic style. The old builders who originated, cultivated, and matured this style, recognised five modes of forming the columns and their accessories, which they used in making the great porticoes or entrances to their temples; and it is of these five orders, which are each marked by special characteristics, that the reader is now going to learn a little, which will enable him to recognise them when he meets with them, or any of them, in any building.

The first point with which we should make ourselves acquainted is a knowledge of the laws by which the architect is guided in drawing their several heights and dimensions. A knowledge of these may with propriety be considered the basis upon which the decorative part of the art is chiefly built, and towards which the attention of the artist must ever be directed, even where no orders are introduced. In them originate most of the forms used in decoration ; they regulate most of the proportions ; and to their combination, multiplied, varied, and arranged in a thousand ways, architecture is indebted for its most splendid productions. There are many persons who consider architecture as a confined and imitative art, in the practice of which the artist is bound down to determined forms and dimensions, without the liberty of exercising his ingenuity or introducing an original conception. The orders are but classifications of the known principles of proportion, and are only useful to the student as forms and arrangements, universally allowed to impress the mind with sensations

suited to the character of the structure in which they are employed. The Corinthian and Composite have the air of lightness and elegance; the Ionic is sober and graceful; the Doric and Tuscan are massive, and capable of supporting great weights.




In all the orders of architecture, the column and the entablature form the principal parts, and of them we must speak generally before we describe them individually.

The column C is divided into three parts: the base, the shaft, and the capital represented in the figure, and lettered *b*, *s*, *c*. The entablature, E, is also divided into three parts, the architrave, *a*, the frieze, *f*, and the cornice, *c*. The column is sometimes mounted on a pedestal, P, and that also is divided into three parts, the plinth, *p*, the die, *d*, and the cornice, *c*. Several of these members consist of two or more mouldings, the forms of which should, in all cases, be adapted to the situations in which they are to be placed.

That the column, entablature, and pedestal, if one should be employed, be so proportioned as to present an appearance of order, is of the greatest importance. To effect this object there should be a relation between the height of the column and entablature, the projection of their several members, and also between the diameter and height of the column.

Now, all the measurements of an order have relation to the lower diameter of the column, which is called a module, and is divided into sixty parts, called minutes. In the Doric order, however, a module consists of thirty minutes, and is, therefore, a semi-diameter. The importance of this arrangement as forming a standard measurement is evident. If the several mouldings and members were made to have merely a relation to each other, without any standard of comparison, there would be a great difficulty in drawing the orders to suit particular places; but as all measurements are made in modules and minutes, there can be no difficulty in drawing them to any size that may suit.

The first object, therefore, of an architect, when he has to draw any order to scale, must be to determine the lower diameter of the column, which is to be the module, that is, the scale, by which all the other parts are to be constructed. The diameters of columns vary with their heights, and columns of different orders have not the same diameters when the heights are equal. There is, in fact, in every order a proportion between the height of the column and the lower diameter; and by a knowledge of the relative proportions, the module may be discovered and the order accurately described.

Before we proceed to explain the construction of the several orders, it may be desirable to make a few general remarks on decorative architecture. If the reader will examine any column and its entablature, he will observe that some members project more than others, and are of greater depth. It is an essential rule in architecture that there should be a reason for everything; thus, for instance, the column is introduced to support the entablature, and the pedestal to support the column. So also the members are supposed to support, strengthen, or shelter each other. Thus, in a cornice, the corona or drip, which is a square massy member intended to carry the water drop by drop from the building, is supported by ovolos and covered by a cavetto.

Some apt and judicious remarks have been made on the surprise that many persons have felt that there should be so few orders. "Nothing," it has been said, "seems so

much to have puzzled those who have but little information on the subject as the fact that there are but three orders in architecture; for virtually there are no more: and architects incur the censure of dulness because many others have not been invented. If, however, it be considered that the orders are but compositions constituted of two characters, masculine vigour and feminine delicacy, as in the Doric and Corinthian, and that these qualities become united, as it were, in the matronly Ionic or middle order, we shall no more expect the addition of another order than that of a new colour to the primitive ones, or of a new note to the musical scale. The Tuscan and Composite, reckoned among the Roman orders, are mere modifications of the Doric and Corinthian."

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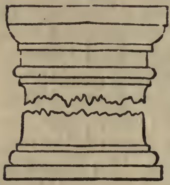
## Part II.—The Characteristics of the Orders.

*The Tuscan Order.* (Fig. 1).—We have no ancient remains of the regular Tuscan order. It was invented by the Romans, and is described by Vitruvius, from whose accounts it has been restored by modern architects. This celebrated Roman author speaks of it in terms which evidently prove that, by many architects in his day it was considered a rustic, almost a deformed style. Palladio has left two examples, but of these one is said to be unpleasingly rustic, and the other too rich and injudiciously composed. The portico of St. Paul's Church, Covent Garden, is the most perfect specimen in this country. The proportions usually adopted are as follows: The height of the column seven diameters, that is, considering the order as a kind of Doric, fourteen modules; and the entablature three modules and a half.

Fig. 1.



The entablature may then be divided into ten equal parts, three of which are to be appropriated for the height of the architrave, three for the frieze, and the remaining four for the cornice. The capital of the column has the height of one module, and the base has the same; so that

the height of the shaft, including the ring or fillet which separates the shaft and column called the cincture, must be twelve modules.

Some architects have, with what we consider a great want of taste, introduced a sort of bandage round the columns, called, by professional men, rustic work. This has been done at the palaces of Pitti, in Florence, and Luxembourg, in Paris, and at Burlington House, in Piccadilly. Nothing can be more ugly, and certainly the deformity cannot be justified by the first axiom in architecture, "There must be a use for everything."

*The Doric Order.* (Fig. 2.)—The Grecian Doric is almost universally made without a base, but the Roman has one in nearly all instances, and the moderns have in this particular followed them, whether judiciously or not we leave the reader to determine. The argument frequently used to prove the absolute necessity of introducing a base is little less than ridiculous. Some writers are so completely prepossessed with the notion that the ancients invented the Doric order from a consideration of the structure of a man, that they compare a column without a base to a man without feet. Some have said that it is difficult to assign any satisfactory reason why the ancients should have made columns without bases; but two reasons may be suggested, one of which assuredly is perfectly valid. Either the architects of antiquity had not yet thought of employing bases to their columns, or they omitted them in order to leave the pavement clear, the angles and projection of bases being stumbling blocks to passengers, and so much the more troublesome, as the architects of those times frequently placed their columns very near each other. Connect with the latter cause the fact that a base but ill suits the extreme simplicity of the Doric order, and there

Fig.

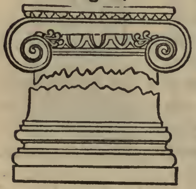
will be little reason to doubt that we may explain its omission in all the most beautiful remains of Grecian Doric.

The shaft is sometimes quite plain, and sometimes fluted at the top and bottom only, but more frequently is decorated with flutings the whole height, and twenty in number. There are no fixed proportions for this order, as the column varies from five to eight diameters; when eight diameters, that is sixteen modules, are used, the entablature is four modules high. The entablature being divided into eight parts, two are given to the architrave, three to the frieze, and the remaining three to the cornice. Vitruvius gives one module as the height of the Doric capital, but this is scarcely enough; in the Colosseum in Rome it is thirty-eight minutes. To show how great a difference there is in the proportions of different specimens of Doric, it may be mentioned that in the temple at Pæstum the height of the column was only four diameters eight minutes, the architrave forty-two minutes, the frieze forty and a half, the cornice twenty-one and a half.

It must here be mentioned that the frieze of the Doric order is ornamented at intervals with two whole and two half channels, called triglyphs. The interval between the triglyphs is called a module. Sometimes the module is left quite plain, and at other times decorated with sculptures; the scull of the ox, pateras, garlands, and gladiators, were commonly introduced by the ancients.

*The Ionic Order.* (Fig. 3.)—The capital is the characteristic feature of the Ionic order. It consists of four spiral projections, called volutes, two of which are placed in the front and two at the back of the column, and they are supported by an enriched ovolo. The capital was more or less decorated by the ancients, according to the taste of the architect or the purpose for which the building was to be employed. The height of the column is nine diameters, and the entablature is one-fourth the height of the column. To arrange and proportion the members of the entablature divide it

Fig. 3.



into ten equal parts, and appropriate three to the height of the architrave, three to the frieze, and the remaining four to the cornice.

Objections have been made to the antique Ionic capital, because its front and side faces are not alike. This particularity, says some ancient writer, occasions great difficulty wherever there are breaks in the entablature, or where the decoration is continued in flank as well as in front; for either all the capitals in the flank must have the baluster side outward, or the angular capitals will have a different appearance from the rest, neither of which is admissible. But in the Temple of Fortune, at Rome, the corner capitals have their angular volutes in an oblique position, inclining equally to the front and side, and offering volute faces both ways. This plan overcomes the difficulty. There is an angular capital from the Temple of Erectheus in the British Museum, which may be examined by our readers when an opportunity offers.

*The Corinthian Order.* (Fig. 4.)—The capital of the Corinthian order consists of two rows of eight leaves each, attached to a bell-formed mass, with angular volutes; between the volutes there are two smaller spirals or helices. This is by far the richest of all the capitals, and the other parts of the order are made to correspond with it. The shaft of the column is fluted, and the frieze is often enriched with sculptures; the cornice also is enriched, and the corona is supported by carved modillions (ornaments resembling brackets), with an ornamental scroll on each side, and an enriched leaf beneath. The column is ten diameters high, and the entablature is one-fifth the height of the column; divide the entablature into ten equal parts, and three parts may be given to the architrave, three to the frieze, and four to the cornice.

Fig. 4.

*The Composite Order.* (Fig. 5.)—The Composite was never considered by the ancients as a distinct order; for

Vitruvius evidently refers to it when he says that Corinthian capitals of various kinds were employed, but the general proportions remained the same. This is, in fact, nearly all that can be said on the subject; for if the reader will make himself acquainted with the Composite capital, he may apply to it all the details of the Corinthian order as above stated.

Fig. 5.

In preparing this account of the orders of architecture, we have endeavoured to explain the principles and proportions by which the architect is directed in his designs; and although we cannot divest our descriptions of all technicalities, they will not, it is hoped, with the explanations that have been given, be impediments to an acquaintance with the subject.

## Exercise in Meanings and Derivation—XX.

*Divide and accentuate each word, and give its meaning and derivation.*

| | | | |
|---|---|---|---|
| **invented** | **cincture** | **pateras** | **modillions** |
| **architects** | **bandage** | **gladiators** | **composite** |
| **rustic** | **axiom** | **spiral** | **technicalities** |
| **deformed** | **simplicity** | **projections** | **impediments** |
| **injudiciously** | **omission** | **volutes** | **acquaintance** |
| **portico** | **fluted** | **baluster** | **enriched** |
| **fillet** | **triglyphs** | **helices** | **channels** |

## Notes.

1. PALLADIO, Andrea, a celebrated Italian architect, was born in 1518, and died in 1580. He erected several magnificent buildings in his native town Vicenza, and other cities of Italy, and published in 1570 a "Treatise on Architecture," which is a standard work on the subject, and has been frequently reprinted.

2. VITRUVIUS, Marcus, a Roman architect of great eminence, who flourished under Julius Cæsar and Augustus His work "De Architecturâ," or "Concerning Architecture," is an epitome of all that had been previously written on this subject by Greek and Roman architects. It was first printed about 1480.

## SUGAR: ITS PROPERTIES AND MANUFACTURE.

The sugar which is used for domestic purposes is extracted from a plant growing abundantly in the West Indies and other hot countries. The juice obtained from the sugar cane undergoes a variety of changes before it is fit for the market: to these we must first direct the attention of our readers. The vegetable character of the plant and the peculiarities of its physiology will not come under our consideration; our object will be to explain its manufacture, and the chemical changes it suffers under particular circumstances.

When the sugar canes are quite ripe they are cut down and carried to a sugar house, where they are passed between two heavy iron cylinders fixed in a vertical position. By this means all the juice of the plant is pressed out, and is conveyed into larger copper vessels for evaporation. A small quantity of slaked lime and wood ashes are then added, and the boiling commences; the lime is added to neutralise any uncombined acid, which would prevent the crystallisation. As the boiling goes on a thick scum is formed on the surface of the liquid, which is continually removed. This boiling with lime and wood ashes is repeated several times, the juice being successively carried off into smaller vessels. When it has become a thick fluid, it is again boiled with lime and alum, and is afterwards poured into wooden coolers, where it in part crystallises. There is now nothing more to do than to pour the whole mass into the hogsheads in which it is to be exported. The molasses or treacle, however, will not crystallise, and therefore a number of holes are bored in the bottom of the hogsheads, that it may be separated from the sugar; this being done the holes are filled up, and the hogsheads are ready for the European markets. A gallon of juice yields about a pound of raw sugar.

The refined or loaf sugar is produced from the raw by a process called refining. The raw sugar is re-dissolved in lime water, and then boiled with some coagulable substance, such as bullock's blood. About fifty gallons of the fluid, called a skipping, are put into a copper pan, so large that

it shall only cover the bottom a few inches deep, that it may not boil over. A great heat is now applied, and the scum which rises to the top is taken off. In this manner the impurities and the colouring matter of the sugar are removed, and when the syrup has been evaporated to a proper consistency it is allowed to flow into earthen pots of a conical form.

There are many other vegetable substances besides the cane which yield sugar; large manufactories have been formed, at different times, for the production of sugar from beetroot. It is stated that four or five pounds may be obtained from a hundred pounds of root, and that it differs but little in taste from the West India sugar, when properly refined.

Sugar consists of oxygen, hydrogen, and carbon. The oxygen and hydrogen are in the proportions to form water, and there is about 42 per cent of carbon. Now before we proceed to speak of the phenomena produced by sugar, when it enters into composition with other substances, it will be necessary to acquaint ourselves with the chemical characters of carbon.

Pure charcoal is called carbon by chemists. The diamond is a crystallised carbon: it is the hardest substance in nature, and one of the most valuable: the crystals are generally small. The largest diamond ever known was sent from Brazil to the court of Portugal in the eighteenth century. It weighed 1,680 carats (a carat being four grains) or fourteen ounces. Its value was estimated even as high as 224 millions sterling, but it proved to be worth not more than £400,000, as it was not brilliant. The original weight of the Koh-i-noor, or "mountain of light," found in the mines near Golconda, in 1550, and surrendered to the British crown in 1849, weighed originally 800 carats; but this, by cutting and recutting, has been reduced to 102 carats. Its value is estimated at two millions. Carbon has a very strong affinity for oxygen, and, on this account, it is frequently used in the arts to deoxidize the metals, and indeed it will steal the oxygen of most substances at a proper temperature.

Carbon is a component part of all vegetable and animal

substances, coal, bitumen, and many minerals. There is, perhaps, no question in science so completely wrapt in mystery as the origin of the varieties in the vegetable kingdom. The number of simple substances entering into the composition of plants is exceedingly small, and carbon always preponderates; yet the tints of blossoms and flowers are almost as various as the species, and there is, perhaps, no one plant which has not a specific use, suited to administer to the support or pleasure of man. There are some which are food to the cattle that support or cover him; there are others which supply him with nutritious food, or are adapted to cure his diseases; while all will afford him gratification, if he possesses a mind capable of appreciating the beauty of their forms, structures, and harmony of colours. How these various properties are obtained from so few elementary principles the art of the chemist cannot explain. There are some vegetables which produce sugar, some resin, some gum, and some oil; and yet in all these products, carbon, oxygen, and hydrogen are the component substances. The indefinite variety which there must be in the interior organisation of vegetables, to enable different orders to prepare such different substances from the same elements, renders this subject too intricate and minute for our investigation: we feel the insufficiency of our faculties. The will of God is the ultimatum of all human knowledge.

Nothing can be more consolatory to a truly devout mind than to feel that all terrestrial existence is dependent on God. Deeply interesting as it may be to form and decompose substances by the agency of chemical affinities, and thus to catch a glimpse of the causes which uphold the present state of things, we may continue our inquiries until the mind is overpowered with its conceptions of the ever-varying changes going on around us, and we can only be satisfied by a conviction that God is directing all to the sustenance of man. We know much, but there is much more that we do not know. That which has been acquired is the result of long and patient study. Science should, therefore, teach us to be humble; for every step we take proves that nothing less than an Almighty power

could produce and sustain such a rich system of existence. St. Pierre has shown, in his "Studies of Nature," how beautifully the vegetable world is adapted to the support of animal life, and how this is made subservient to the welfare of man. "The sluggish cow pastures in the cavity of the valley; the bounding sheep on the declivity of the hill; the scrambling goat browses among the shrubs of the rock; the duck feeds on the water plants of the river; the hen, with attentive eye, picks up every grain that is scattered and lost in the field; the pigeon of rapid wing collects a similar tribute from the refuse of the grove, and the frugal bee turns to account even the small dust on the flower. There is no corner of the earth where the whole vegetable crop may not be reaped. Those plants which are rejected by one are a delicacy to another, and even among the finny tribes contribute to their fatness. The hog devours the horse-tail and the hen-bane; the goat, the thistle and the hemlock. All return in the evening to the habitations of man, with murmurs, with bleatings, with cries of joy, bringing back to him the delicious tributes of innumerable plants, transformed by a process the most inconceivable into honey, milk, butter, eggs, and cream."

We must now proceed to speak of a substance which has a certain relation to sugar, so far at least as being composed of two of its ingredients. This is oxalic acid, a virulent poison, which, from its great resemblance in character to Epsom salts, has been frequently taken by mistake, and has proved fatal. Nothing, however, is more easy than to detect the difference between these two substances: if a drop of oxalic acid be placed on the tongue, a sour taste will be perceived. It may also be discovered without tasting, for if the solution be applied to a piece of blue paper the colour will be instantly changed to a reddish brown. A chemist will detect the difference between the two substances by the form of their crystals. If neither of the tests already mentioned are tried, it will be sufficient to dissolve a little of the acid in a spoonful of water, and scrape into it a little chalk, or whiting, and an effervescence will be produced; the same effect will not be observed if Epsom salts be used in the same way. When

a person has taken oxalic acid into the stomach, and the stomach pump cannot be immediately used, the best remedy is to administer common chalk or magnesia in warm water, in large doses, and to excite vomiting as quickly as possible: many lives might have been saved by the prompt use of this antidote.

Oxalic acid was discovered by Scheele: it consists of oxygen and carbon, like carbonic acid, but has a less quantity of oxygen than that substance, though a much more powerful acid. It is found in combination with potash in the juice of the sorrel, and is so easily produced from sugar that it is sometimes called the acid of sugar. It is used by the chemist to detect the presence of lime, and by the calico-printer in the process of his manufacture. Seven grains of pure oxalic acid will, it is said, communicate a sensible acidity to two pounds of water; and a single grain will communicate to 3,600 grains the property of reddening the vegetable blues. When heated in the open air an acrid white smoke is given off, which exceedingly irritates the lungs.

Starch is another substance greatly resembling sugar in its chemical composition, for it consists of carbon, oxygen, and hydrogen. It is obtained from the flour of most grains, and, in fact, from almost any vegetable substance. The following is the method of obtaining starch from the potato, a root well suited for the manufacture of that substance. For the purposes of experiment it may be made in the following manner: Take any grain reduced to a fine powder, and well wash it in cold water; then strain off the liquid through a fine sieve, and the fibrous and grosser parts will be separated; decant the liquid which contains the soluble parts of the vegetable matter, and, having repeatedly washed the farina with cold water, dry it with a gentle heat.

The method in which starch is prepared for the market. The grain is steeped in water till it becomes soft, and yields a milky fluid on pressure. It is then put into coarse sacks, which are strongly pressed in vats filled with water: the sacks are then removed, and the starch subsides to the bottom. Being suffered to remain some time, the

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supernatant fluid ferments, and acetous acid is formed, which dissolves the impurities and leaves only the starch. On drying, the starch splits into columnar masses of a small size, forming prisms of considerable regularity.

Starch may be converted into sugar, showing the intimate relation between their compositions, a fact which forms a connecting link between the previous remarks and those with which this lesson was commenced.

## Exercise in Meanings and Derivation.—XXI.

*Divide and accentuate each word, and give its meaning and derivation.*

| | | |
|---|---|---|
| **extracted** | **specific** | **subservient** |
| **neutralise** | **harmony** | **solution** |
| **refined** | **insufficiency** | **acrid** |
| **manufactories** | **decompose** | **supernatant** |
| **mystery** | **sustenance** | **evaporation** |
| **appreciating** | **virulent** | **molasses** |
| **investigation** | **acidity** | **conical** |
| **consolatory** | **decant** | **deoxidise** |
| **conviction** | **cylinders** | **nutritious** |
| **browses** | **exported** | **intricate** |
| **antidote** | **consistency** | **ultimatum** |
| **fibrous** | **affinity** | **conceptions** |
| **physiology** | **administer** | **declivity** |
| **crystallisation** | **elementary** | **effervescence** |

## Notes.

1. St. Pierre, Jacques Bernadin Henri de, a French miscellaneous writer, who after serving for some years as a soldier, first in Russia and then in France, abandoned the military profession to devote himself to literature. Among his numerous works, in which are included his admirable "Studies of Nature" and "Harmonies of Nature," special mention must be made of "The Indian Cottage" and "Paul and Virginia," two stories which have been translated into almost every European language. He was born in 1737, and died in 1814.

2. Scheele, Carl Wilhelm, a noted Swedish chemist, was born in 1742, and died in 1786. He greatly extended our knowledge of acids, and at his death, through his labours, more than double the number were reckoned in chemistry than there had been when he began his labours. He determined the nature of the constituents of ammonia and prussic acid, and many colours in the painter's stock still bear his name as their discoverer.

# THE EYE AND ITS STRUCTURE.

## Part I.—The Formation of the Eye.

### Glossary of Scientific Terms, &c.

**sphe′-ri-cal**...*round, like a ball or sphere.* [Gr. SPHAIRA, a sphere or globe.]

**scle-rot′-i-ca**...*the hard outer coating of the rye.* [Gr. SKLEROS, hard.]

**cor′-ne-a**......*the transparent hard skin covering the pupil in front of the eye.* [Lat. CORNU, horn.]

**mem′-bra-nous**......*having a resemblance to membranes or thin tissues or fibres.* [Lat. MEMBRANA, a membrane.]

**cho′-roid**...*the inner membrane of the eye next the sclerotica.* [Gr. CHORION, a particular membrane so called; EIDOS, form.]

**pu′-pil**......*the circular opening in front of the eye through which light is admitted to the interior.* [Lat. PUPILLUS, the pupil of the eye; from PUPUS, boy; PUPA, girl, in allusion to the minute figure seen on looking into another person's eye.]

**i′-ris**.....*the coloured ring surrounding the pupil.* [Lat. IRIS, the rainbow.]

**di-ver′-gent**...*bending away or apart from.* [Lat. DI, apart; VERGO, I bend or incline.]

**con-tracts′**.....*draws together, decreases in size.* [Lat. CON, together; TRAHO, I draw; participle, TRACTUS, drawn.]

**op′-tic**....*of or belonging to the eye or sight.* [Gr. OPTIKOS, anything seen.]

**ob-scu′-ri-ty**..........*darkness, absence of light.* [Lat. OBSCURUS, dark.]

**im-bued′**........*smeared, deeply tinged or coloured.* [Lat. IMBUO, I drink in.]

**hu′-mours**.....*fluids of animal bodies.* [Lat. HUMEO, I am moist.]

**fi′-bres**...*thread-like substances in animal and vegetable bodies.* [Lat. FIBRA, a thread.]

**ret′-i-na**......*the net-like expansion of the optic nerve on which the image of objects is depicted in the eye.* [Lat. RETINA, a net.]

**vit′-re-ous**......*glassy, or resembling glass.* [Lat. VITRUM, glass.]

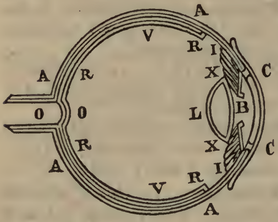
**ex-pan′-sion**.......*an enlargement or spreading out.* [Lat. EX, from; PANDO, I lay open.]

**fo′-cus**...a *point in which rays of light may be concentrated or brought together by a lens.* [Lat. FOCUS, a hearth.]

**dis-tinct′**...*clear, plain.* [Lat. DISTINCTUS, clear; from DISTINGUO, I mark out.]

**di-lates′**...*extends, stretches out to a wider extent.* [Lat. DI, apart; FERO, I bear; participle, LATUS, carried or borne.]

The body of the eye is of a spherical form. It has two membranous coverings—the external one, A A, is called the sclerotica; this has a projection in that part of the eye which is exposed to view, C C, which is called a cornea,




because, when dried, it has nearly the consistence of a very fine horn, and is sufficiently transparent for the light to obtain free passage through it. The second membrane which lines the cornea and envelopes the eye is called the choroid; this has an opening in front, just beneath the cornea, which forms the pupil B, through which the rays of light pass into the eye. The pupil is surrounded by a coloured border of fibres, called the iris, I I, which by its motion always preserves the pupil in a circular form, whether it be expanded in the dark or contracted by a strong light.

The construction of the eye is so admirable that it is capable of adapting itself more or less to the circumstances in which it is placed. In a faint light the pupil dilates so as to receive an additional quantity of rays, and in a strong light it contracts in order to prevent the intensity of the light from injuring the optic nerve. The eyes suffer pain when, from darkness, they suddenly come into a strong light; for the pupil being dilated, a quantity of rays rush in before it has time to contract. And when we go from a strong light into obscurity we at first imagine ourselves in total darkness, for a sufficient number of rays cannot gain admittance into the contracted pupil to enable us to distinguish objects; but in a few minutes it dilates, and we clearly perceive what was before invisible. The choroid is imbued with a black liquor, which serves to absorb all the rays that are irregularly reflected, and to convert the body of the eye into a more perfect camera obscura, or dark chamber. When the pupil is expanded to the utmost extent it is capable of admitting ten times the quantity of light that it does when most contracted. In cats and

animals which are said to see in the dark, the power of dilation and contraction of the pupil is still greater ; it is computed that their pupils may receive one hundred times more light at one time than at another. Within these coverings of the eye-ball are contained three transparent substances called humours. The first occupies the space immediately behind the cornea, and is called the aqueous humour, from its liquidity and its resemblance to water. Beyond this is situated the crystalline humour, X X, which derives its name from its clearness and transparency ; it has the form of a lens, and refracts the rays of light in a greater degree of perfection than any that have been constructed by art. It is attached by fibres to each side of the choroid. The back part of the eye, between the crystalline humour and the retina, is filled by the vitreous humour, V, which derives its name from a resemblance it is supposed to bear to glass or vitrified substances. The membranous coverings of the eye are intended chiefly for the preservation of the retina, R R, which is by far the most important part of the eye, as it is that which receives the impression of the objects of sight. The retina consists of an expansion of the optic nerve, of perfect whiteness ; it proceeds from the brain, enters the eye at O, on the side next the nose, and is finely spread over the interior surface of the choroid. The rays of light which enter the eye by the pupil are refracted by the several humours in their passage through them, and unite in a focus on the retina.

Rays proceed from bodies in all possible directions. We must, therefore, consider every part of an object which sends rays to our eyes as points from which the rays diverge as from a centre. Divergent rays, on entering the pupil, do not cross each other ; the pupil, however, is sufficiently large to admit a small pencil of them ; and these, if not refracted to a focus by the humours, would continue diverging after they had passed the pupil, would fall dispersed upon the retina, and thus the image of a single point would be expanded over a large portion of the retina. The divergent rays from every other point of the object would be spread over a similar extent of space, and

would interfere and be confounded with the first, so that no distinct image could be formed on the retina. The refraction of the several humours unites the whole of a pencil of rays, proceeding from any other point of an object, in a corresponding point on the retina, and the image is thus rendered distinct and strong.

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## Part II.—Imperfections of Sight.

That imperfection of sight which arises from the eyes being too prominent is owing to the crystalline humour being too convex; in consequence of which it refracts the rays too much, and collects them into a focus before they reach the retina. From this focus the rays proceed diverging, and consequently form a very confused image on the retina. This is the defect of short-sighted people; and it is remedied by bringing the object nearer to the eye, for the nearer an object is brought to the eye the more divergent the rays fall upon the crystalline humour, and consequently do not so soon converge to a focus. This focus, therefore, either falls upon the retina, or at least approaches nearer to it, and the object is proportionally distinct. The nearer, therefore, an object is brought to the crystalline, or to a lens, the further the image recedes behind it. But short-sighted persons have another resource for objects which they cannot permit to approach their eyes. This is to place a concave lens before the eye, in order to increase the divergence of the rays, the effect of a concave lens being exactly the reverse of a convex one. By the assistance of such glasses, therefore, the rays from a distant object fall on the pupil as divergent as those from a less distant object; and, with short-sighted people, they throw the image of a distant object back as far as the retina. Those who suffer from the crystalline humour being too flat apply an opposite remedy; that is to say, a convex lens, to make up for the deficiency of convexity of the crystalline humour. Thus, elderly people, the humours of whose eyes are decayed by age, are under the necessity

of using convex spectacles; and when deprived of that resource they hold the object at a distance from their eyes, for the more distant the object is from the crystalline the nearer the image will be to it. These two opposite defects are easily comprehended; but the greatest difficulty remains, namely, how any sight can be perfect: for if the crystalline humour be of a proper degree of convexity to bring the image of distant objects to a focus on the retina, it will not represent near objects distinctly; and if, on the contrary, it be adapted to give a clear image of near objects it will produce a very imperfect one of distant objects.

Now to obviate this difficulty, and adapt the eye either to near or to distant objects, power is given to us to increase or diminish in some degree the convexity of the crystalline humour, and also to project it towards or draw it back from the object, as circumstances require. In a young, well-constructed eye, the fibres to which the crystalline humour is attached have so perfect a command over it that the focus of the rays constantly falls on the retina, and an image is formed, equally distinct, both of distant objects and of those which are near. We cannot, however, see an object distinctly if we bring it very near to the eye, because the rays that fall on the crystalline humour are too divergent to be refracted to a focus on the retina. The confusion, therefore, arising from viewing an object too near the eye is similar to that which proceeds from a flattened crystalline humour: the rays reach the retina before they are collected to a focus.

We conclude this subject with the following beautiful observations on the eye, from the pen of Addison, one of the best of our English authors:—

"Our sight is the most perfect and most delightful of all our senses. It fills the mind with the largest variety of ideas, converses with its object at the greatest distance, and continues the longest in action without being tired or satiated with its proper enjoyments. The sense of feeling can indeed give us a notion of extension, shape, and all other ideas that enter at the eye, except colours; but, at the same time, it is very much straightened and confined

in its operations to the number, bulk, and distance of its particular objects. Our sight seems designed to supply all these defects, and may be considered as a more delicate and diffusive kind of touch, that spreads itself over an infinite multitude of bodies, comprehends the largest figures, and brings within our reach some of the most remote parts of the universe.

"It is this sense which furnishes the imagination with its ideas. We cannot, indeed, have a single image in the fancy that did not make its first entrance through the sight; but we have the power of retaining, altering, and compounding those images, which we have once received, into all the varieties of picture and vision that are most agreeable to the imagination; for, by this faculty, a man in a dungeon is capable of entertaining himself with scenes and landscapes more beautiful than can be found in the whole compass of nature. A beautiful prospect delights the soul, as much as a demonstration; and a description in Homer has charmed more readers than a chapter of Aristotle. Besides, the pleasures of the imagination have this advantage above those of the understanding, that they are more obvious, and more easy to be acquired. It is but opening the eye, and the scene enters. The colours paint themselves on the fancy with very little attention of thought or application of mind in the beholder. We are struck, we know not how, with the symmetry of anything we see, and immediately assent to the beauty of an object without inquiring into the particular causes and occasions of it. A man of polite imagination is let into a great many pleasures that the vulgar are not capable of receiving. He can converse with a picture, and find an agreeable companion in a statue. He meets with a secret refreshment in a description, and often feels a greater satisfaction in the prospect of fields and meadows than another does in the possession. It gives him, indeed, a kind of property in everything he sees, and makes the most uncultivated parts of nature administer to his pleasures; so that he looks upon the world, as it were, in another light, and discovers in it a multitude of charms that conceal themselves from the generality of mankind."

## Exercise in Meanings and Derivation.—XXII.

*Divide and accentuate each word, and give its meaning and derivation.*

| | | |
|---|---|---|
| **imperfection** | **variety** | **demonstration** |
| **remedied** | **remote** | **vulgar** |
| **reverse** | **compounding** | **generality** |
| **obviate** | **landscapes** | **confused** |
| **perfect** | **polite** | **concave** |
| **infinite** | **conceal** | **defects** |
| **altering** | **convex** | **collected** |
| **faculty** | **recedes** | **extension** |
| **symmetry** | **opposite** | **retaining** |
| **multitude** | **flattened** | **vision** |
| **prominent** | **satiated** | **description** |
| **converge** | **universe** | **uncultivated** |
| **deficiency** | **picture** | **application** |

## Notes.

1. ADDISON, Joseph, son of the Rev. W. Addison, rector of Milston, in Wiltshire, was born in 1672. He rose to be Secretary of State in 1717, but literature was his proper province. The elegance of his Latin composition attracted the admiration of the University of Oxford. As a poet he was smooth and polished, and his prose is considered a model for the composition of pure English. His essays are preserved in the *Tatler*, *Spectator*, and *Guardian*, which were periodical literary papers of his time. He died in 1719, supported by a calm and cheerful reliance upon the truths of Christianity.

2. ARISTOTLE, often called the Stagyrite, from Stagyrium, the place of his birth, was one of the most celebrated philosophers of Greece, and preceptor to Alexander the Great. He was born B.C. 384, and died B.C. 323.

3. HOMER, a Greek poet, who flourished in the ninth century before the Christian era. He was probably an Asiatic Greek, but the exact place of his nativity is unknown. He is represented to have been a strolling bard, and blind; but be that as it may, the poems which bear his name have never been equalled for sublimity of thought and sweetness of expression. The "Iliad" of Homer is a poem descriptive of the siege of Troy in Asia Minor, and his Odyssey details the wanderings of Ulysses, king of Ithaca, one of the Ionian Islands, in returning home from the Trojan war. These poems have been elegantly translated into English by Pope.

## MINERAL VEINS AND BEDS.

### Glossary of Scientific Terms, &c.

**mi-nu'-ter** .........*closer, more careful.* [Lat. MINUTUS, small, from MINUO, I lessen.]

**in-qui'-ries**..........*researches, whether by questioning or earnest thought.* [Lat. IN, into; QUÆRO, I seek.]

**de-vel'-op-ments**......*unfoldings, openings by degrees.* [Lat. DE, from; VOLVO, I roll out.]

**cre-a'-tions**........*works of the Creator or God, the maker of all things.* [Lat. CREO, I create or make.]

**com-pen-sa'-tion** .....*amends, remuneration.* [Lat. CON, intensive; PENSO, I weigh.]

**fis'-sures**........*cracks in rocks.* [Lat. FISSURA, a cleft or slit, from FINDO, I cleave.]

**re-plen'-ished** ....*filled again.* [Lat. RE, again; PLENUS, full.]

**prim'-i-tive** .........*of the first formation.* [Lat. PRIMUS, first.]

**in-ter-mixed'**..........*mingled together.* [Lat. INTER, between; MISCEO, I mingle; participle, MIXTUS, mingled.]

**cha-ot'-ic**......*in a state of the utmost disorder.* [Gr. CHAOS, confusion.]

**an-ti'-qui-ty**.........*great age, duration of time.* [Lat. ANTIQUUS, old.]

**junc'-tion**.....*joining, point of meeting.* [Lat. JUNGO, I join; participle JUNCTUS, joined.]

**dis-cussed'**.........*talked over, formed the subject of debate or dispute.* [Lat. DIS, asunder; QUATIO, I shake, as if the subject were shaken asunder or into separate parts by careful examination.]

**ad-u-la'-ri-a**......*a stone which lapidaries call moonstone.* [Derived from ADULA, the summit of a Swiss mountain.]

**o-blique'** ..........*in a slanting direction.* [Lat. OBLIQUUS, crooked.]

**frag'-ments** ......*broken pieces.* [Lat. FRANGO, I break.]

**pre-dom'-i-na-ting**......*being in excess, or more plentiful.* [Lat. PRÆ, over or above; DOMINO, I rule.]

**de-ci'-sive**........*decided, firm, sure, positive.* [Lat. DE, from; CÆDO, I cut.]

**grov-el'-ling**.....*mean, low, of a debased nature.* [Ger. KRABBELN, to crawl.]

**sub-ja'-cent**.......*lying under.* [Lat. SUB, under; JACIO, I lie.]

**sub-si'-dence**....*sinking from below.* [Lat. SUB, under; SEDEO, I sit or settle down.]

**in-dic'-a-tive**........*tending to show or point out, demonstrative.* [Lat. IN, intensive; DICO, I say or declare.]

**u-ni-form'-ly** ......*constantly, always, without any exception.* [Lat. UNUS, one; FORMA, form.]

**gray'-wack-e**.........*a kind of sandstone, composed of quartz, felspar, silicious slate, and clay.* [Derived from the German name for this rock, GRAUWACKE.]

**spec'-u-la-tor** ....*one who lays out money without certainty of return, in the hope of getting great gain.* [Lat. SPECULOR, I look out.]

**gran'-u-lar** .........*composed of small grains.* [Lat. GRANUM, a grain.]

**a-bun'-dance**...*plenty, a great quantity.* [Lat. ABUNDO, I abound; from flowing over like a wave as it were; UNDA, wave.]

**in-ter-vened'** ...*come between.* [Lat. INTER, among; VENIO, I come.]

The further research extends and the minuter our inquiries into the structure of the globe, the more interesting and wonderful become the developments of science. While the eye is roving over the scenes of beauty and grandeur around and above us, the foot treads upon a world of splendid creations beneath; and frequently where the outward forms of nature become the least attractive, there is an ample compensation in its subterranean wealth. From the operation of powerful causes, fissures of greater or less extent, and running through masses of rocks in different directions, have from time to time been filled with various substances, some of a richly metallic character. These fissures so replenished have been denominated veins. If filled with strong matter, they are called dykes; if with tin or copper, lodes. If they intersect the strata they are termed rakes; if they lie between them, pipes or flats. Metalliferous ores, however, are found also in beds or strata. These are generally seen in primitive and secondary rocks, and are usually horizontal in their position. All the ores in the great mining district of Sweden occur in beds in the primitive mountains. Copper, iron, and lead are occasionally found in beds in this class of rocks; sometimes gold and silver are intermixed. Lead and zinc, as well as iron, are frequent in secondary mountains in beds.

The manner in which the mineral veins were originally produced has been much discussed. The advocates of fire as the great agent in the constitution of the globe maintain that they arose from the contractions while the masses

were cooling, and the force from below propelling the subjacent formations into the cavities. Those who plead for the chief agency of water believe that the fissures were caused by the subsidence of the rocky masses, and that they were filled from above by depositions from the chaotic fluid.

It has been supposed that certain circumstances are indicative of the comparative age of the formation of different veins. Thus, those of copper are said always to divide and pass through the veins of tin, which bespeaks the superior antiquity of the latter. It is also affirmed that those veins which are not metalliferous, the north and the south, always divide both the copper and the tin; the latter, therefore, are the oldest. Other veins are also found passing through all these, and, consequently, showing a more recent formation. In primitive metalliferous mountains the width of the veins seldom exceeds a few feet, their length a few hundred fathoms. The great mineral deposits of England are chiefly in veins; this is uniformly the case in Cornwall, where they consist of copper and tin.

The junction of veins with the beds they traverse is often attended with curious circumstances, which it is difficult to account for on chemical principles, though in explaining them it is no less difficult to resort to any other. What is moonstone at a short distance from the lodes will often become graywacke in their vicinity; or the grain of the granite will be altered, or it will become slaty; or the felspar will change into adularia, or one of its three ingredients will disappear, or a fourth be added. Such anomalies are particularly numerous and striking by the side of whin-dykes. Along the line of contact, common sandstone is sometimes converted into jasper or lydian stone, chalk into granular marble, coal into coke or plumbago, clay-slate into horn-blende slate.

The Cornish veins run nearly east and west; those which take the direction of north and south seldom contain metals. The metalliferous veins which run east and west dip towards the north or south, while those which are not metalliferous, and run north and south, incline towards

the east or west. Some are very oblique in either case, and others nearly perpendicular. It is thought in Cornwall that the tin lodes point rather to the north of east, and the copper lodes rather to the south.

The principal lead veins of Devonshire, the Beer-Alston lode, runs nearly north and south, as do most of the lead veins in Cornwall. Those of Cumberland and the adjoining counties are chiefly east and west. Some of the veins of Cornwall have been traced to the distance of three or four miles, but their termination has not yet been ascertained. Several mines are more than a thousand feet in depth. Generally the tin and copper veins are from one to three feet in width, and these are less intermingled with other substances than those of greater dimensions. A vein of tin ore, in the Whealan Coates mine, was only three inches wide, but so rich as to repay working. Some of the veins of copper in Herland mine were only six inches wide, and eventually passed away in filaments, but they yielded copper of a very rich quality. A vein in the adjoining hill was also found to be very productive, and varied in width from twelve to twenty-four feet.

It must be observed, however, that the veins are not filled with the metallic ores; but these, in fact, occupy only a small comparative portion of the vein, and are therefore called bunches. The rest is filled with stony or earthy fragments of various kinds.

Those parts of a vein which are not metalliferous are termed deads. Sometimes there are large vacant spaces.

Abundance of water is found in veins, especially in those which are richest in ore. The sides of metalliferous veins are covered with a hard dark crust, termed the walls, and there is usually a small whitish clay vein adhering to one or other wall.

Ores of copper and tin do not often occur together at any considerable depth. They seldom commence at less than eighty feet below the surface, and the tin or copper is intermixed with lead ore, iron pyrites, zinc, spar, or other substances. If tin is first discovered, in sinking 80 or 100 feet more all trace of it is often lost, and copper only occurs; though in some veins tin continues to the

depth of 1,000 feet ; but if copper is first discovered, tin is rarely found in the same vein below it. In the mine called Cook's Kitchen, and one or two others, copper and tin have continued to the greatest depth ; sometimes one and sometimes the other predominating.

Occasionally in searching for the tin or copper vein, on the other side of a north or south non-metalliferous vein, which seems to have split it, the former is for a time lost, and many years of labour and loss have intervened before its course could be regained. Instances have occurred in which it has been again discovered 120, or even 400 or 450, feet north or south of that part on the other side of the intersecting vein. These vary from an inch to ten or twelve feet in width, and heave the copper and tin veins out of their proper direction. Where a copper and tin vein meet the former passes through the latter, and displaces or heaves it from its course.

In some of the mining districts of Cornwall the metalliferous veins are extremely numerous ; but the great difficulty is to ascertain those which will prove valuable or productive. The temptation to search is strong from their multitude ; but the frequent failure of flattering hopes, which have no decisive basis on which in any case to found them, has too frequently ruined the eager speculator.

This is again another instance of those wonderful counterbalancings of evil and good by which divine wisdom has "set one thing over against another," and taught us at once to check the eagerness of ambition, and to raise our grovelling desires from the perishing and unsatisfactory pursuits of this world to the nobler objects of that which is to come.

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## Exercise in Dictation—VII.

**The blushing beauty of the rose, and the modest blue of the violet, are not in the flowers themselves, but in the light that surrounds them: odour, softness, and beauty of figure, are their own; but it is light alone that dresses them up in those robes which shame the haughty monarch's pride.**

## SERPENTS: THEIR GENERAL MECHANISM.

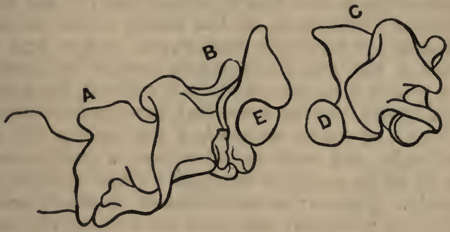
### Part I.—Habits and Structure of Body.

The hotter portions of the globe, exuberant alike in animal and vegetable productions, are those especially productive of animals ferocious in their nature and formidable from their powers. It is there that we see the lion, and the tiger, and the jaguar; it is there that we see the elephant, and the hippopotamus, and the rhinoceros; it is there, among forests of primeval antiquity, impenetrable jungles, and morasses teeming with luxuriant vegetation, or among mouldering ruins overgrown with tangled brushwood, that we see the serpent of monstrous growth, terrific, yet resplendent. To these hot and glowing regions the serpent tribe indeed seem in a certain sense peculiar: it is their congenial realm—they swarm in countless myriads, of every hue and size. But as we recede from these into temperate climates the race becomes less numerous and less formidable, till in our northern latitudes we arrive at the outskirts of their territory, and find the species limited, and their aggregate numbers few and dispersed. Hence he who wishes to study the habits and instincts of this dreaded race must betake himself to a tropical clime, where one species or another will arrest his attention wherever he goes. Some he sees slender as whipcord, and of great length, twined around the boughs or twigs of trees and shrubs, assimilating in colour to the foliage which conceals them. Rapidly and silently they glide among the branches, even to the tops of the highest trees, in pursuit of insects and the eggs of young birds; others dart across his path and plunge amidst the jungle ere his eye can trace their colours. Let him follow the mazes of the river, or track the borders of the lake, there, its tail twined around a tree or mouldering log, and its body floating on the surface of the water in undulating curves, may he mark the mighty boa, or python, waiting till evening brings the antelope or the deer to drink. Sudden as the lightning's flash the monster envelopes the hapless wretch in his heavy folds, and, straining, crushes every bone to pieces. When the last feeble struggles of

the victim have ceased, slowly uncoiling, the snake, regardless of all but his prey, proceeds to gorge the mangled carcass, swallowing it by degrees, the jaws distended by the effort and dripping with saliva. Let him wander among the ruins or mouldering tenements of that sandy plain—there are the haunts of the deadly cobra : he starts to see it with eyes glowing like sparks of fire, with distended hood and quivering tongue, raise its head in threatening mood, as disturbed by his close approach ; it hesitates whether to attack or flee ; it darts into its hole. Rejoiced at his escape he returns to his house ; but he finds all in confusion : a venomous snake has entered his sleeping-room unawares, and bitten one of his servants, who lies a pallid corpse. It is well, however, that all are not thus terrific from their powers, or from the deathly nature of their bite : multitudes are harmless (at least as far as man is concerned), and as beautiful in their colouring as graceful in their forms ; nor are they incapable of being tamed, or, when tamed, unsusceptible of attachment. Still they are not favourites : some nations, it is true, have regarded certain species with a kind of religious homage ; but man is evidently at enmity with them. There is something repulsive about their form and movements ; the fixedness of their gaze ; the fiery, glistening eye ; the unalterable expression of cunning and ferocity ; their winding, silent, and insidious mode of progress ; the rapid, noiseless manner in which the head towering aloft, as elevated on the look-out for prey, is instantaneously lowered on the approach of the victim ; their subtleness ; their daring ; their predatory habits ; the poison of many ; the bodily powers of others ; all combine to render them objects of alarm or aversion.

Our present design is not to sketch the habits nor enter into a detail of the specific characters of serpents, but rather to explain a few points in their structure which evidently tend to fit them for their destined mode of life. The elongated form, the absence of limbs, the scaly covering by which they are protected, are known to all. Passing over these external features let us look at the skeleton, the frame work of all vertebrate animals. In serpents it

is peculiarly simple, consisting alone of the skull, the vertebral column, and the ribs. The breast bone, or *sternum*, is wanting; but some species possess obscure rudiments of the limbs concealed beneath the skin. If we




**A, B, C, vertebræ of a snake. A and B are conjoined, but C is removed, to show the articulating ball, D, which is fitted into the cup, E, of the intermediate vertebra, B.**

examine the vertebral column we find it to consist of a series of bones united to each other by ball and socket articulations, the head of each separate vertebra being received into a deep cup-like cavity of the one succeeding it.

The articulations of this column, destined, as in higher animals, to protect the spinal cord (which runs through the canal formed in the usual way), are by this mechanism rendered especially secure; but each bone enjoys in consequence thereof but a limited degree of motion, as it regards the one in immediate connection with it; and with reason, because if each bone could form a right angle with its neighbour the spinal cord must inevitably suffer, and the laxity of joints admitting such freedom would render dislocation easy, a thing above all others to be guarded against in a long serpent, composed of a series of short bones articulated together. The spinal column of the serpent is therefore locked and secure. But it may be asked, Is not the snake capable of twining in the most extraordinary manner? True; but the pliability of the snake's body consists not in the mobility of each joint separately, but in the number of joints into which it is

divided producing unitedly a degree of pliability which a few joints, however free, could not bestow. The body of the snake is not only capable of flexion but of close and intimate application to every rugged inequality of a tree on the earth; and this faculty is the result of its minute subdivisions. The body of the snake is never bent in acute angles, but always in flowing, easy curves or circles. From each of these distant bones, so multitudinous in their number, which form the vertebral column (and in one species of python we have counted two hundred and fifty-six, exclusive of those composing the tail), a rib arises from each side, and both together form a great portion of a circle, so as to embrace nearly the whole circumference of the body. These ribs are restricted to the vertebræ of the body only; they do not arise from those of the tail. Let us here call to mind the progressive motion of a snake: it seems to creep along as if by magic; the fact is that these ribs are the efficient agents of progressive motion. The snake has no solid breast-bone into which, as in mammalia and birds, they are inserted (such a bone indeed is out of the question), and which would confine their extent of motion; on the contrary, each rib plays freely, having its appropriate and most energetic muscles; and it is on the points of these ribs that the weight of the snake rests. Hence the series of curves made by the body of the snake in order to pass along; for while the muscles keep the anterior ribs firm (at each progressive stroke) the remainder of the body is brought up in zig-zag curves; the posterior ribs are then kept firm, while, as from a fixed fulcrum, the fore parts are thrown forward. The broad transverse scales, or plates of the under surface of the snake (called *squamæ*, in contradistinction to the small imbricated scales of the back, called *scutæ*), aid also in this mode of progressive motion. Each of these plates has a cartilaginous connection with its fellow pair of ribs, and the whole are thus made to tally in their mode of action; overlapping each other in regular succession, they tend, as their edges are raised in progressive order, to prevent the slipping back of the body, and supply, from the point of one rib to the point of its fellow, a ridged line.

## Exercise in Meanings and Derivation.—XXIII.

*Divide and accentuate each word, and give its meaning and derivation.*

| | | |
|---|---|---|
| **exuberant** | **unsusceptible** | **energetic** |
| **ferocious** | **attachment** | **anterior** |
| **formidable** | **favourites** | **zig-zag** |
| **teeming** | **homage** | **transverse** |
| **quivering** | **articulations** | **envelopes** |
| **hesitates** | **pliability** | **uncoiling** |
| **venomous** | **rugged** | **saliva** |
| **pallid** | **progressive** | **tenements** |
| **specific** | **tropical** | **instantaneously** |
| **elongated** | **assimilating** | **subtleness** |
| **rudiments** | **jungle** | **predatory** |
| **vertebral** | **undulating** | **aversion** |
| **mouldering** | **enmity** | **cartilaginous** |
| **resplendent** | **repulsive** | **tally** |
| **congenial** | **movements** | **succession** |
| **aggregate** | **insidious** | **ridged** |

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### PART II.—STRUCTURE OF THE SKULL.

We shall now pass to a consideration of the skull of serpents, as far, at least, as regards the general mechanism of its structure. The snake, as is well known, is capable of swallowing its undivided food, many times larger in bulk than the circumference of its own body; nay, the disproportion is almost incredible. That the skin, the gullet, and the stomach are capable of enormous dilatation is a wise provision in its favour; but, with every allowance for the dilating power of the skin and internal viscera, how, it may be asked, can the prey be forced through the jaws, composed of bone, which is hard and unyielding? Here we see one of those beautiful instances of harmony which are ever apparent in the works of the Almighty. The bones forming the jaws and face (so to call it) of the snake, unlike what is seen in other animals, where they are firmly locked together, and where the lower jaw moves on closely-bound hinges, are all loose and unconnected except by skin and ligaments, which yield with the utmost facility. The upper jaw is in two pieces, with a separate intermaxillary bone between the points of each; and the bones of the face, frittered down into their elemental parts, are all loose and

disunited. The lower jaw is also composed of two distinct lateral branches, each branch being in fact itself made up of two portions, united by a loose kind of suture. Instead of being secured by firm joints to the skull, the lower jaw is attached on each side by a lax articulation to a movable bone, called the tympanic portion of the temporal bones. The articulation admits of a natural kind of dislocation, so that it gives way in the act of swallowing, and recovers itself when the prey is fairly engulfed.

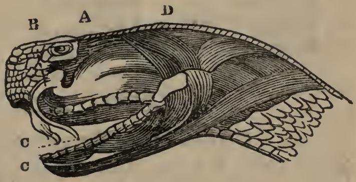
Such is the general plan of construction of the serpent's skull. There are, it is true, infinite degrees of variation in the details in different species, but the grand outline is the same.

Serpents may be characterised as poisonous, that is, producing death by their bite; or innoxious, that is, producing by their bite no mischief beyond the wound itself. Among the innoxious tribe we may place the boa, the python, the common snake of England, and many more. They possess a double row, above, of sharp-pointed teeth, inclining regularly backwards, so that the hand may be passed down over them with impunity, but not drawn back, for then they pierce the skin immediately. Hence they offer no impediment to the passage of food, but securely detain the struggling victim. Of this double row of teeth on each side of the mouth above, one runs along the edge of the jaw-bone, the other along the bone of the palate. In each ramus, or branch of the lower jaw, there is but a single row.

In poisonous serpents, such as the rattlesnake, the cobra, the British viper, and others, the teeth are somewhat differently arranged. It is a common thing to hear persons talk of serpents stinging; the serpent, however, has no sting—the fatal wound is produced by a bite.

If we examine the jaws of a poisonous serpent, we shall find the bones forming the upper jaw to be small and freely movable upon a long osseous peduncle which passes backward. They are placed on each side of the mouth, and bear each a long recurved pointed tooth, pierced by a tube leading from a large gland situated beneath the eye. Thus the fluid secreted by this gland passes through the

tube into the bottom of the wound which the poison fang inflicts. When not required for use these poison fangs lie concealed in a fold of the gum, the bones to which they are attached having the requisite degree of mobility, so that, when the snake is about to bite, they are brought forward, and in the act of biting a few drops of the deadly fluid are instilled into the puncture. The other teeth above are ranged along the bones of the palate, and the lower jaw is but partially furnished. The annexed sketch shows the arrangement of the fangs of a poisonous snake, and the source from which the poison is distilled through the tooth into the wound. From this the peculiar structure of the terrible weapons with which a poisonous snake is armed may be clearly seen.




**Fangs of a Poisonous Snake.**

**A. Poison bag under left eye B. Duct from poison bag to fang. C C. Fangs recurved. D. Ligament by which the poison is pressed from poison bag into fang.**

There is something more than usually repulsive in the aspect of poisonous serpents : their thick, broad head, and their wide jaws armed with the horrible poison fangs, together with their brilliant eyes, give them a ferocious expression, and man and beast instinctively recoil from their presence. Whether all poisonous serpents have these marked poison fangs is, however, much to be doubted. Many without them have back teeth of great size and grooved, and possess a large maxillary gland ; and such are considered in the countries they inhabit exceedingly poisonous, the truth of which opinion is said to be too often proved by the sad experience of the natives, as well as having been confirmed by the direct experiments of several naturalists of great eminence.

It is said the sweet oil, or olive oil, is one of the best antidotes for the bite of a poisonous snake.

## Exercise in Meanings and Derivation.—XXIV.

*Divide and accentuate each word, and give its meaning and derivation.*

| | | |
|---|---|---|
| **mechanism** | **lateral** | **osseous** |
| **dilatation** | **temporal** | **mobility** |
| **ligaments** | **impunity** | **grooved** |
| **disunited** | **stinging** | **gullet** |
| **tympanic** | **conceals** | **unconnected** |
| **innoxious** | **recoil** | **elemental** |
| **palate** | **incredible** | **articulation** |
| **secreted** | **unyielding** | **engulfed** |
| **repulsive** | **frittered** | **detain** |
| **disproportion** | **suture** | **peduncle** |
| **viscera** | **dislocation** | **puncture** |
| **intermaxillary** | **impediment** | **eminence** |

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## CLOUDS AND RAIN.

### Glossary of Scientific Terms, &c.

**lev′-i-ty**......*lightness, freedom from weight.* [Lat. LEVIS, light.]

**spe-ci′-fic** ............*that which determines its kind or species, peculiar to itself.* [Lat. SPECIES, a kind; FACIO, I make.]

**so-lu′-tion**...*the act of dissolving in a dissolved state.* [Lat. SOLVO, I loose; participle, SOLUTUS, loosed.]

**sat′-u-ra-ted**......*filled until it can hold no more.* [Lat. SATURO, I fill to repletion; from SATIS, enough.]

**in-ter-me′-di-ate**...*partaking of the nature of both, midway between.* [Lat. INTER, between; MEDIUS, the middle.]

**trans-for-ma′-tion** ...*change from one condition into another.* [Lat. TRANS, across; FORMA, shape or form.]

**con-ver′-sion**............*change, alteration.* [Lat. CON, together; VERTO, I turn or change; participle, VERSUS, turned.]

**sup-po-si′-tion** ...*assumption, anything assumed or believed to be true.* [Lat. SUB, under; PONO, I place; participle, POSITUS, placed.]

**zone**..*a belt or girdle; in the case of clouds a stratum, like those into which the earth would be divided if cut by planes passing through the limits of the zones.* [Gr. zonē, a girdle.]

**ve-sic′-u-lar**...*formed of small globules, like little bladders.* [Lat. VESICULA, a little bladder; from VESICA, a swelling.]

**re′-gions**...*districts, tracts of country.* [Lat. REGIO, a district; from REGO, I rule or mark out.]

**el-e-va'-tion**...*height from the surface of the ground.* [Lat. E, from; LEVO, I raise.]
**cu'-ri-ous** ...*singular, remarkable, worthy of note.* [Lat. CURIOSUS, painstaking; from CURA, care.]
**gauge**.........*anything whereby measurement of capacity, strength, &c., may be made.* [Fr. JAUGE, a measuring rod.]
**de-form'**....*make out of shape, alter so as to render misshapen.* [Lat. DE, from; FORMO, I make or form.]
**moun'-tain-ous**...*traversed by ranges of mountains.* [Lat. MONS, a mountain.]
**ir-reg'-u-lar** ......*rough, shapeless, not according to rule.* [Lat. IN, not; REGULA, a rule.]
**ar-ti-fi'-cial**...*made by art, or otherwise than by natural means.* [Lat. ARS, art; FACIO, I make.]
**e-rup'-tions**..............*violent discharges, outbursts.* [Lat. E, from; RUMPO, I break; participle, RUPTUS, broken.]

When water is exposed to the air it is gradually converted into vapour, which, on account of its specific levity, ascends into the atmosphere. This vapour presents itself in various forms. When the air holds it in solution it is invisible, just as salt dissolved in water is invisible; but where the air is saturated the watery particles become visible, either in the form of clouds and mists suspended in the atmospheres, or in that of rain, dew, snow, and hail, falling to the ground.

Clouds and mists differ only in this, that the former float in the air, whereas the latter extend along the ground. They are understood to consist of a collection of small vesicles or hollow spheres, and to occupy a sort of intermediate state between water and invisible vapour. The causes which produce these vesicles are not well understood; though change of temperature and electricity have probably the principal share in the transformation. The height of clouds is very various. In ascending to the summits of mountains the traveller frequently passes through a zone of clouds, and beholds the vesicular vapour, of which it is composed, stretched under his feet like a vast plain covered with snow; and even on Chimborazo, the loftiest peak of the Andes, there are always to be seen, at an immense height, certain whitish clouds resembling flakes of wool. These clouds, which are perhaps many

miles from the surface of the earth, are supposed to owe their elevation to negative electricity repelling them from the ground, in the same way as mists are supposed to owe their depression to positive electricity attracting them towards it.

Rain falls from the clouds when the vesicular vapour, of which they are composed, unites into drops. The fall of the drops of rain, after they are formed, is easily accounted for from the attraction of gravity; but the cause of the conversion of vesicular vapour into rain-drops is not better understood than the cause of the conversion of vapour into vesicles; though it is highly probable that electricity is an agent in the one case as well as in the other. If the change be owing to the diminution of this fluid, we have a ready explanation of the well known fact that mountainous are the most rainy countries, mountains constituting so many points for the drawing off the electric fluid. This supposition is further rendered very probable by the fact that no rain falls in those regions where thunder is unknown, as in the environs of Lima and on the coast of Peru. The quantity of rain that falls in different regions of the globe is very different. It is most abundant within the torrid zone, and decreases in proportion to the distance from the equator. The annual fall at Grenada, in 12° N. lat., is 126 inches; at Calcutta, in 22° N. lat., it is 81 inches; at Rome, in 41° 54′, it is 39 inches; in England, 32 inches; and at St. Petersburg, in lat. 59° 16′, it is only 16 inches. Even in different places in the same country the quantity that falls is different. But the most curious fact of all, in the natural history of rain, is the difference of quantity which is collected at different heights at the same time. In one year a rain gauge on the top of Westminster Abbey received 12 inches; another on the top of a house in the vicinity received 18 inches; and a third, on the surface of the ground, received 22 inches.

Snow is another of the forms which the vapours of the atmosphere assume. It consists of aqueous vapour, congealed either while falling or when in the air previous to falling. The first crystals produced at a great height in the atmosphere, determine, as they descend, the crystalli-

sation of aqueous particles, which, without their presence, the surrounding air would retain in a state of solution. The result is the formation of hexagonal darts, or stars of six rays, when the weather is sufficiently calm, and the temperature not too high to deform the crystals by melting off their angles ; but when the atmosphere is agitated, and the snow falls from a great height, the crystals clash together, unite in groups, and form irregular flakes.

Hail, according to all appearance, is a species of snow, or snowy rain, which has undergone a variety of congelations and superficial meltings in its passage through different zones of the atmosphere of different temperatures. Its formation evidently depends on electricity. It is by an electrical apparatus that we can produce artificial hail, and it is well known that volcanic eruptions are often followed by the fall of hailstones of an enormous size.

### Note.

For further details respecting Meteorology, and the formation of clouds, mist, hail, rain, snow, dew, &c., see John Heywood's "Class Book of Modern Science," Chap. VIII.

## GOLD AND SILVER.

The comparative scarcity of the two precious metals, gold and silver, have given to them a greater value than most other mineral substances. They are used in nearly all civilised countries as a circulating medium, and a value is attached to them in others. In many nations the national bank circulates paper with a printed form, by which the parties issuing promise to pay a certain amount to the holders of these papers whenever presented for that purpose. Bank of England notes are of this kind, and are current in all places where there is a confidence that the bank directors can pay what they have promised. The notes are not, in themselves, of any real value ; still it is a great convenience to have them received generally as the representative of a certain amount of money. It is true there is no value received, but as long as the notes can be

converted into gold, an intrinsically valuable substance, they are suitable mediums of commerce. Supposing that in some large transaction it were necessary for one merchant to pay another the sum of several thousand pounds, and there were no notes, the whole amount must be given in sovereigns, which would not only be very heavy and inconvenient to carry, but considerable time must be lost in counting over the coins. It would, in fact, be almost impossible to carry on the commerce of any country without some circulating medium of the kind we have mentioned. Gold, however, is in this country the standard to which all values are referred. If we speak of the value of a note, we say it is worth five, ten, twenty, or some greater number of sovereigns; and a book is worth a certain part of a sovereign, as, for instance, a shilling, twenty of which are considered to have a value equal to one sovereign.

Now, money has only one real use; it enables us to provide those things which are necessary for the sustenance and comfort of life. As such, it is the duty of every man to make some attempts to obtain it, that he may provide for his own wants, and the temporal happiness of those dependent on him. But "the love of money," says the Scripture, "is the root of all evil." It is a disposition of mind which may give birth to all the worst principles of our depraved nature. A miser is the most pitiable, as well as the most despicable of men. It is scarcely possible to imagine a condition more fraught with danger than that of the man who has set his heart resolutely on the acquisition of money. The probability is that he will be induced to take dishonest means to secure his object. Yet how few are there who can utter with sincerity the wish comprehended in the prayer of Agar: "Give me neither poverty nor riches; feed me with food convenient for me: lest I be full, and deny thee, and say, Who is the Lord? or lest I be poor, and steal, and take the name of my God in vain." Men are now frequently estimated by their possessions, and not by their characters. It matters but little in the view of the world how riches have been obtained; their possession is sufficient to exalt him who owns them. It is not thus that the great Master of the church estimates His

followers, and Christians must have a higher standard. We must, however, leaving these reflections, now proceed to explain the chemical characters of the two metals which are the representatives of wealth, and the means by which their ores are reduced to a metallic state.

Gold is a light yellow-coloured metal. It is the heaviest of all metals except platinum, and is so ductile and malleable that it may be beaten into leaves $\frac{1}{280000}$ part of an inch thick. It is not acted upon by the atmosphere, water, or even acids; nitro-muriatic acid and chlorine are the only substances that will dissolve it. Gold leaf introduced into chlorine gas takes fire and burns. Its presence when in solution is detected by dropping into the liquid the green sulphate of iron; a brown precipitate is produced. When ammonia is made to combine with the oxide of gold, a very dangerous compound is formed, called fulminating gold. This substance explodes violently when its temperature is raised, and also when there is a slight friction. Accidents have often occurred from a careless use of this and similar substances. Young persons are sometimes found trifling with these dangerous compounds, and we cannot, therefore, too strongly impress upon them the folly of such conduct, for dangerous or even fatal consequences may be the result.

Gold has the property of combining with other metals. It forms a most excellent alloy with a small quantity of copper; for the compound is harder than the pure metal, and retains its lustre. The gold coin of this country consists of gold and copper; in every twelve parts there are eleven of pure gold.

When chemistry first attracted the attention of inquiring men as a science, there were many who devoted all their attention and time to the vain hope of discovering a method of making gold. It was generally supposed at this period that the baser metals might be transmuted into gold. In the old alchemical works rules are given for this purpose; but they are expressed in such enigmatical terms, that it is quite impossible to understand what is meant by the authors. For very many years a vain search for a method of transmuting the baser metals into gold,

and for a universal elixir, capable of curing all diseases, was the only employment of the chemist ; and even in the present day there are some persons who pretend to have discovered the art. In some modern works curious accounts are given of the production of gold from lead and other common metals, for which it is not easy to account. The following is one of these, from Major Kinneir's Travels in Armenia and Koordistan : " A few days before my arrival at Bassora, in August, 1814, Mr. Colquhoun (pronounced *Co-hoon'*), the acting resident in that place, received a message from an Arabian philosopher, requesting a private interview, in order to communicate a most important secret. Mr. Colquhoun consented ; and next morning the mysterious stranger was introduced to him. Embracing the knees of the resident, he said he was come to supplicate the protection of the English from the cruel and continued persecutions of his countrymen, who, understanding that he had the power of transmuting the basest metals into gold, daily put him to the torture to wring his secret from him. He added that he had just made his escape from Grane, where he had long been starved and imprisoned by the sheik, and that he would divulge everything he knew to Mr. Colquhoun, provided he was permitted to reside in the factory. My friend agreed to receive him, and in return he faithfully promised to afford a convincing proof of his skill. He accordingly retired, and soon afterwards returned with a small crucible and chafing dish of coals ; and when the former became hot he took four small papers, containing a whitish powder, from his pocket, and asked Mr. Colquhoun to fetch him a piece of lead. The latter went into his study, and, taking four pistol bullets, weighed them, unknown to the alchemist. These, with the powder, he put into the crucible, and the whole was immediately in a state of fusion. After the lapse of about twenty minutes, the Arabian desired Mr. Colquhoun to take the crucible from the fire, and put it into the air to cool. The contents were then removed by Mr. Colquhoun, and proved to be a piece of pure gold, of the same weight as the bullets. The gold was subsequently valued at ninety piastres in the bazaar." It is difficult to

know what can be said to this curious story ; for it appears singular that a poor Arabian should present ninety piastres to an English resident for protection. He never returned to Mr. Colquhoun, for he was carried off by the sheik of Grane, who broke into his house the same night.

Gold is chiefly found in Peru and Brazil ; but it is sometimes obtained from Siberia and Hungary. In many of the African rivers also it has been found. In the province of Sonora, in Mexico, it is said the Spaniards discovered a plain fourteen leagues in extent, in which they found wash-gold, and some of the masses of which weighed seventy-two ounces. A quantity of immense value was collected here in a very short time. To obtain this metal, all the European adventurers who visited America soon after its discovery were not slow to commit any enormity. Slavery and death were the attendants upon every step in discovery, and the cupidity of the early navigators can only be compared with the rapid fall of the nations most intimately connected with the Europeans who first visited the shores of America.

Silver is a white metal, exceedingly ductile and malleable, heavy and sonorous. It is found in many countries, and in various states. Native silver is chiefly obtained from the mines of Potosi, and is occasionally found in copper mines. Sulphuret of silver and oxide of silver are more common ; the silver mines of Mexico and Peru are the richest in the world. Baron Humboldt states that in the space of three centuries, 316,023,883 pounds (troy) of the pure metal were obtained, and that the quantity would be sufficient to form a solid globe of silver, 91,206 feet in diameter. A large proportion of silver is frequently alloyed with lead. There is one mine in the county of Antrim, in Ireland, so rich that one pound of silver is obtained from every thirty pounds of lead ore. The principal use of silver is for coining ; but it is also employed for many ornamental and useful articles, such as spoons, candlesticks, teapots, and forks ; but, as it is a comparatively soft metal, it is commonly alloyed with copper. The indelible ink for marking linen and cotton is nothing more than a solution of nitrate of silver with a little gum water.

The nitrate of silver, when melted and run into moulds, is sold by the chemists as lunar caustic.

There are two methods of purifying the ores of the precious metals, that is, separating the metals from the substances with which they are combined. One is called smelting or roasting, the other amalgamation; it is to the latter we must chiefly confine our attention. An amalgam is a metallic compound. It was early known that mercury had the property of uniting with the precious metals, but it was, according to Humboldt, first applied to useful purposes in the amalgamation of silver, in Mexico, about the year 1557. It is supposed that the first application of the process in Europe was made at Konigsberg, in Norway, about 1738.

The machine by which amalgamation is now performed consists of a series of barrels which revolve on separate axes, but are connected with a general axis, so that any one may be set in motion or stopped without interfering with any of the others. The charge for each barrel consists of the powdered calcined ore, mercury, water, and iron. The barrels are made to revolve for sixteen or eighteen hours, and during that period the following chemical effects are produced: the silver is separated from its acid by the iron, and combines with the mercury, forming an amalgam; the salts which are formed are dissolved in the water. The amalgam is then removed to a distilling furnace, where, by the action of an intense heat, the mercury is sublimated, and the silver left in its pure state.

There is an amalgamation works on the river Mulda, near Freyburg, which was established in 1794. There are also two smelting works in the same neighbourhood; the amalgamation succeeds best when the silver ore produces about 75 ounces to the ton. The persons, therefore, who superintend the works usually select the ores, so as to bring the quantity as near to this average as possible.

The choice between amalgamation and smelting, must, of course, be regulated by the situation of the place where the works are to be erected, and the facility offered for obtaining the necessary materials.

## Exercise in Meanings and Derivation.—XXV.

*Divide and accentuate each word, and give its meaning and derivation.*

| | | |
|---|---|---|
| **scarcity** | **ductile** | **crucible** |
| **circulating** | **malleable** | **cupidity** |
| **medium** | **detected** | **amalgamation** |
| **current** | **fulminating** | **disposition** |
| **fraught** | **torture** | **depraved** |
| **acquisition** | **enormity** | **miser** |
| **sincerity** | **caustic** | **despicable** |
| **estimated** | **transaction** | **transmuted** |
| **mysterious** | **commerce** | **alchemical** |
| **obtained** | **sustenance** | **enigmatical** |
| **indelible** | **temporal** | **elixir** |
| **confidence** | **explodes** | **subsequently** |
| **representative** | **friction** | **sonorous** |
| **intrinsically** | **alloy** | **sublimated** |
| **suitable** | **baser** | **superintend** |

## Notes.

The following account of our gold, silver, and copper coinage may prove useful and not uninteresting. The coins now in circulation are: In gold, the sovereign and half-sovereign; in silver, the crown, halfcrown, florin, shilling, sixpence, and threepenny-piece; in copper, the penny, halfpenny, and farthing. The fourpenny-piece has recently been called in to prevent the confusion naturally arising from having two coins, namely, the fourpenny and threepenny pieces, of the same superficial area, though not of the same thickness; and the crown and halfcrown might well be withdrawn from circulation, the former on account of its weight and inconvenient size, and the latter on account of its similarity in size to the florin. The following statement will show that these coins are no longer coined, though they still form part of our circulating medium. The Maundy money therein mentioned is money given by the sovereign to as many poor persons as he or she may be years old on the Thursday preceding Good Friday. The donation in money if accompanied by gifts of food and clothing. The custom was begun in 1363, by Edward III., when he was fifty years old, and is still continued.

The second annual report (for 1871) of the Deputy Master of the Mint, just published, shows that the coins struck at the Mint during the year 1871, for circulation in the United

Kingdom, were of three different metals, and of eleven different denominations, viz :

Gold—sovereigns and half-sovereigns; silver—florins, shillings, sixpences, fourpences (Maundy money only), threepences, twopences (Maundy money only), and pence (Maundy money only); bronze—pence and halfpence.

The total number of pieces struck was 26,216,704, and their value, real or nominal, amounted to £10,498,686 10s. 5d., as may be seen from the following table :—

| COINS. | NUMBER. | VALUE. | | | TOTAL. | | |
|---|---|---|---|---|---|---|---|
| Gold :— | | £ | s. | d. | £ | s. | d. |
| Sovereigns .............. | 8,767,250 | 8,767,250 | 0 | 0 | | | |
| Half-sovereigns ........ | 2,062,970 | 1,031,485 | 0 | 0 | | | |
| | | | | | 9,798,735 | 0 | 0 |
| Silver :— | | | | | | | |
| Florins.................. | 3,425,605 | 342,560 | 10 | 0 | | | |
| Shillings ................ | 4,910,010 | 245,500 | 10 | 0 | | | |
| Sixpences .............. | 3,662,684 | 91,567 | 2 | 0 | | | |
| Fourpences (Maundy) .. | 4,427 | 77 | 2 | 4 | | | |
| Threepences ............ | 1,004,121 | 12,551 | 10 | 3 | | | |
| Twopences (Maundy) .... | 4,753 | 39 | 12 | 2 | | | |
| Pence (Do.) .... | 9,286 | 38 | 13 | 10 | | | |
| | | | | | 692,335 | 0 | 7 |
| Bronze :— | | | | | | | |
| Pence .................. | 1,290,318 | 5,376 | 6 | 6 | | | |
| Halfpence .............. | 1,075,280 | 2,240 | 3 | 4 | | | |
| | | | | | 7,616 | 9 | 10 |
| Making a total of | | .. | | .. | 10,498,686 | 10 | 5 |

The standard gold coin of the United Kingdom is made of an alloy of 11 parts of fine gold and 1 part of copper, which is added to impart hardness to the gold, so that it may suffer less waste from wear in circulation. From a pound troy of standard gold—that is, 11 parts gold and 1 of copper—are coined $46\frac{29}{40}$ sovereigns, so that the weight of each is exactly 5 dwts. $3\frac{172}{223}$ grs., or nearly 123·274 grains. The Mint prices of standard gold is £3 17s. $10\frac{1}{2}$d. per ounce.

The standard silver coin consists of 37 parts of pure silver and 3 parts of copper. A pound troy of this alloy furnishes 66 shillings, so that the weight of a shilling is 3 dwts. $15\frac{3}{11}$ grs. The Mint price of standard silver is 5s. 6d. per ounce.

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